

International Energy Conservation Code

2000 Edition
Houston Amendments

Shaded sections are from the 2001 supplement to the IECC. Where supplement changes were also modified locally, that portion of the sections code text is not shaded.

CHAPTER 1
ADMINISTRATION AND ENFORCEMENT

SECTION 101

SCOPE AND GENERAL REQUIREMENTS

101.1 Title. This code shall be known as the *International City of Houston Energy Conservation Code* of [NAME OF JURISDICTION], and shall be cited as such. It is referred to herein as “this code”.

Simply identifies the name of the code for local adoption ordinance.

CHAPTER 2

DEFINITIONS

DUCT. ~~A tube or conduit utilized for conveying air. The air passages of self-contained systems are not to be construed as air ducts.~~ is any tube or conduit for transmission of air. This definition shall not include:

1. A vent, a vent connector or a chimney connector.
2. Any tube or conduit wherein the pressure of the air exceeds one (1) pound per square inch.
3. The air passages of listed self-contained systems.

DUCT SYSTEM. ~~A continuous passageway for the transmission of air that, in addition to ducts, includes duct fittings, dampers, plenums, fans and accessory air-handling equipment and appliances.~~ includes all ducts, duct fittings, plenums and fans assembled to form a continuous passageway for the distribution of air.

For consistency these definitions mirror the Houston Mechanical Code but do not substantially change the meaning.

EXTERIOR WALL. An above-grade wall enclosing conditioned space which is vertical or sloped at an angle of (60) degrees (1.1 rad) or greater from the horizontal (see "Roof Assembly"). Includes between floor spandrels, peripheral edges of floors, roof and basement knee walls, dormer walls, gable end walls, walls enclosing a mansard roof, and basement walls with an average below grade-wall area which is less than 50 percent of the total opaque and non-opaque area of that enclosing side.

SUNROOM ADDITION. A one-story structure added to an existing dwelling with a glazing area in excess of 40 percent of the gross area of the structure's exterior walls and roof.

THERMAL ISOLATION. A separation of conditioned spaces, between a sunroom addition and a dwelling unit, consisting of existing or new wall(s), doors, and/or windows. New wall(s), doors, and/or windows shall meet the prescriptive envelope component criteria in Table 502.2.5.

WINDOW PROJECTION FACTOR. A measure of the portion of glazing that is shaded by an eave, or overhang, or fin.

Clarifies that certain vertical elements may provide a shading projection .

CHAPTER 3

DESIGN CONDITIONS

TABLE 302.1
EXTERIOR DESIGN CONDITIONS

CONDITION	VALUE
Winter ^a , Design Dry-bulb (°F)	<u>28°F</u>
Summer ^a , Design Dry-bulb (°F)	<u>96°F</u>
Summer ^a , Design Wet-bulb (°F)	<u>80°F</u>
Degree days heating ^b	<u>1365</u>
Degree days cooling ^b	<u>3058</u>
Climate zone ^c	<u>3</u>

For SI: °C = [(°F)-32]/1.8.

- a. ~~The outdoor design temperature shall be selected from the columns of 97 1/2 percent values for winter and 21/2 percent values for summer from tables in the ASHRAE *Handbook of Fundamentals*. Adjustments shall be permitted to reflect local climates which differ from the tabulated temperatures, or local weather experience determined by the code official.~~
- b. ~~The degree days heating (base 65°F) and cooling (base 65°F) shall be selected from NOAA "Annual Degree Days to Selected Bases Derived from the 1961-1990 Normals," the ASHRAE *Handbook of Fundamentals*, data available from adjacent military installations, or other source of local weather data acceptable to the code official.~~
- c. ~~The climate zone shall be selected from the applicable map provided in Figures 302.1(1) through 302.1(51) on the following pages.~~

The appropriate design criteria from NOAA and ASHRAE data is defined in the table, thus eliminating the need for explanatory footnotes.

Climate Zone - Although the City of Houston spreads into 6 counties in both zones 3 and 4, it is desirable to have one zone designation for enforcement. The IECC map for Harris county lists zone 4 and was derived from NOAA data at Bush Intercontinental Airport. That airport sits on the northernmost edge of Harris county and NOAA data was not available for the first 10 years of the normalized period .

Data could be derived from the nearby Ellington military base, but that airport sits on the southernmost edge of Harris County.

NOAA data was obtained at Hobby Airport for the entire 1961-1990 period and is considered more appropriate for Houston because the airport is more centrally located. It produces a zone 3 designation.

CHAPTER 4

RESIDENTIAL BUILDING DESIGN BY SYSTEMS ANALYSIS AND DESIGN OF BUILDINGS UTILIZING RENEWABLE ENERGY SOURCES

402.1.1 Standard design. A building designed in accordance with this chapter will be deemed as complying with this code if the calculated annual energy consumption is not greater than a similar building (defined as a “Standard design”) whose enclosure elements and energy-consuming systems are designed in accordance with Chapter 5. Specific building envelope elements of the Standard design shall comply with Section 402.1.1.1 through 402.1.1.4.

Exceptions:

402.1.1.1 Exterior walls. ~~1.~~ The exterior wall assembly *U*-factors for the Standard design shall be selected by climate in accordance with Table 402.1.1(1) 0.085 (Btu/h · ft² · °F).

402.1.1.2 Fenestration U-factor. ~~2.~~ The fenestration system *U*-factor used in the Standard design shall be selected by climate in accordance with Table 402.1.1(2) 0.047 (Btu/h · ft² · °F).

402.1.1.3 Window area. ~~3.~~ The window area of the Standard design, inclusive of the framed sash and glazing area, shall be equal to 18 percent of the conditioned floor area of the Proposed design.

402.1.1.4 Skylights. ~~4.~~ Skylights and other nonvertical roof glazing elements shall not be included in the Standard design, and ceiling *U*-factors used in the Standard design shall not include such elements in their computation.

Inserts the data from tables 402.1.1 (1) and (2) into the text of this code section.

402.1.2.1 Orientation for groups of buildings. The worst possible orientation for the Proposed design, in terms of annual energy use, considering north, northeast, east, southeast, south, southwest, west, and northwest orientations, shall be used to represent a group of otherwise identical designs.

402.1.3.1.1 Orientation, Standard design. As a minimum ~~E~~-equal areas on north, ~~northeast~~, east, ~~southeast~~, south, ~~southwest~~, and west, and northwest exposures shall be assumed.

402.1.3.1.2 Shading calculations, Proposed design. ~~Results from shading calculations on a Proposed design shall not be used for groups of buildings, unless those results constitute the worst possible building orientation in terms of annual energy use, considering all eight of the above orientations for a group of otherwise identical Proposed designs.~~

402.1.3.1.3 Exterior shading, Standard design. Glazing areas in the Standard design shall not be provided with exterior shading such as roof overhangs. Energy performance impacts of added exterior shading for glazing areas which are accounted for in the Proposed design for a specific building shall be permitted, provided that the code official approves the actual installation of such systems.

402.1.3.1.4 402.1.3.1.3 Fenestration system solar heat gain coefficient, Standard design. The fenestration system solar heat gain coefficient (SHGC), inclusive of framed sash and glazing area, of the glazing systems in the Standard design shall be 0.40 for HDD $\leq 3,500$ and 0.68 for HDD $> 3,500$ during periods of mechanical heating and cooling operation. These fenestration system SHGC values shall be multiplied together with (added in series to) the interior shading values as specified in Section 401.1.3.1.5 to arrive at an overall solar heat gain coefficient for the installed glazing system.

Exceptions:

1. Any glazing facing within 45 degrees of true north;
2. Any glazing facing within 45 degrees of true south which is shaded along its full width by a permanent overhang with a projection factor of 0.3 or greater.
3. Any fenestration with attached screens where the screens have a rated shading coefficient of 0.6 or less.

Where the SHGC characteristics of the proposed fenestration products are not known, the default SHGC values given in Table 102.5.2(3) shall be used for the Proposed design.

1. Simplifies the section by eliminating reference to HDD.

2. The exceptions will allow north facing windows, which do not receive direct solar radiation, to be exempt from the minimum SHGC requirement; provides a simple way for south facing windows to effectively achieve summer shade and still receive some solar heat benefit in winter; and specifically allows use of solar screens as one method to achieve the shading effect.

402.1.3.1.5 402.1.3.1.4 Interior shading, Standard design and Proposed design. The same schedule of interior shading values, expressed as the fraction of the solar heat gain admitted by the fenestration system that is also admitted by the interior shading, shall be assumed for the Standard and Proposed designs. The values used for interior shading shall be 0.70 in summer, and 0.90 in winter.

Exception: South-facing solar gain apertures on passive heating Proposed designs analyzed using interior shading values for interior shading specific to those shading measures specified in the Proposed design, with values above used in the Standard design.

402.1.3.2 Reserved. Passive solar. Passive solar building designs shall provide documentation, acceptable to the code official, that fixed external or other acceptable shading is provided to limit excessive summer cooling energy gains to the building interior.

402.1.3.3 Heat storage (thermal mass). The following input values, specific to heat storage (thermal mass), shall be used in calculating annual energy performance:

Internal mass 8 pounds per square foot (39 kg/m²)

Structural mass 3.5 pounds per square foot (17 kg/m²)

Passive solar buildings shall utilize at least 45 Btu/°F (7.92 kJ/K) of additional thermal mass, per square foot (m²) of added glass area, when added south-facing glass area exceeds 33 percent of the total glass area in walls.

402.1.3.4.3 Doors. The exterior opaque door area of the Standard design shall have an equal exterior door area as that of the Proposed design with and shall have a U -factor of 0.2 Btu/h ft² °F [1.14 W/(m² K)]. The U of the Standard design shall be selected to permit calculated U_o wall compliance of the Standard design.

402.1.3.5 Heating and cooling controls. Unless otherwise specified by local codes, heating and cooling thermostats shall be set to the default settings in comply with Table 402.1.3.5 for the Standard and Proposed designs. The input values, specific to heating and cooling controls, shall be used in calculating annual energy performance.

TABLE 402.1.3.5
HEATING AND COOLING CONTROLS

Parameter	Standard design value	Proposed design value
Heating	68°F 70°F	68°F 70°F
Cooling	78°F 75°F	78°F 75°F
Set back/set up	5°F	Maximum of 5°F
Set back/set up duration	6 hours per day	Maximum of 6 hours per day
Number of set back/set up periods per dwelling unit ^a	1	Maximum of 1
Maximum number of zones per dwelling unit ^a	2	2 <u>unlimited</u>
Number of thermostats per zone	1	1

For SI: °C = [(°F)-32]/1.8.

a. Units = Number of living dwelling units in Standard and Proposed designs.

1. Increasing the design heating temperature from 68°F to 70 °F: Houston - Houston's HDD is so low that increasing the heating load temperature is negligible. Often setting becomes a cooling load which is particularly common in the Houston climate. The advantage to setting a higher heating load temp and reducing the point where cooling loads kick in is that the potential for mold growth, which greatly increases when A/C systems are run below 72 degrees Fahrenheit is reduced.
2. Decreasing the design cooling temperature from 78°F to 75 °F: Mold is a distinct concern in the hot and humid climate of Houston and it is necessary to design for seventy five degrees Fahrenheit in order to deal with the mold health issue.
3. Allowing unlimited zones in the proposed design provides the option of introducing additional zones for better efficiency.

402.1.3.8 Site weather data (constants). The typical meteorological year (TMY2), or its "Ersatz" equivalent, from the National Oceanic and Atmospheric Administration (NOAA), or an approved equivalent, for the closest available location shall be used Hobby Airport, Houston, Texas.

References the closest available locations specifically.

402.1.3.12 Heating and cooling system equipment efficiency, Standard design. The efficiency of the heating and cooling equipment shall meet but not exceed the minimum efficiency requirement in Section 503.2. Where the proposed design utilizes an electric resistance space heating system as the primary heating source, the Standard design shall utilize an air-cooled heat pump that meets but does not exceed the minimum efficiency requirements in Section 503.2.

Exception: Zonal electric resistance space heating equipment in buildings in Climate Zones 1a through 4b as indicated in Table 302.1.

SECTION 403

SYSTEM ANALYSIS FOR

RENEWABLE ENERGY SOURCES ANALYSIS

403.1 General. A proposed building utilizing solar, geothermal, wind or other renewable energy sources for all or part of its energy source shall meet the requirements of Section 402, except such renewable energy shall

be permitted to be excluded from the total annual energy consumption allowed for the building by that the provisions of this section shall also apply.

403.1.1 Equivalent energy sources. The Standard design shall use energy sources as determined by Table 403.1.1.

TABLE 403.1.1
EQUIVALENT ENERGY SOURCES

Proposed design energy source		Standard design energy source	
Space heating	Domestic water heating	Space heating	Domestic water heating
Some renewable energy	Some renewable energy	Non-renewable energy source used in proposed space heating design	Non-renewable energy source used in proposed domestic water heating design
Some renewable energy	All renewable energy	Non-renewable energy source used in proposed space heating design.	
All renewable energy	Some renewable energy	Non-renewable energy source used in proposed domestic water heating design	
All renewable energy	All renewable energy	Heat pump meeting requirements of Table 503.2	Electric water heater meeting requirements of Table 504.2

403.1.1.1 Insulated shutters. The windows are provided with operable insulated shutters or other devices which, when drawn or closed, shall cause the window area to reduce maximum outward heat flows to those in accordance with Section 502.1.4.1.

403.1.1.2 Shading. The window areas are shaded or otherwise protected from direct rays of the sun during periods when mechanical cooling is required.

403.1.1 403.1.2 Solar energy systems, active exclusion, one. To qualify for under this exclusion section, such renewable solar energy must be derived from a specific collection, storage, and distribution system. The solar energy passing through windows shall also be considered as qualifying if such windows meet the criteria specified in Sections 403.1.1.1 and 403.1.1.2.

403.1.2 Solar energy exclusion, two. Exclusion shall be granted for solar energy passing through windows where such windows meet the criteria specified in Sections 403.1.2.1 and 403.1.2.2.

403.1.2.1 Insulated glass. The glass is double- or triple- pane insulating glass with a low-emittance coating on one or more airspace surfaces of the glass or insulating glass with a low-emittance plastic film suspended in the airspace.

403.1.2.2 Shading. ~~The glass areas are shaded from direct solar radiation during periods when mechanical cooling is required.~~

403.1.3 Other criteria. ~~Other criteria indicated in Section 402 shall apply to the proposed alternative designs utilizing renewable sources of energy. **Solar energy systems, passive.** To qualify under this section, space heating energy must be derived from the absorption of solar radiation by specific building materials and its release to the conditioned space.~~

403.2 Documentation. ~~Proposed alternative designs submitted as requests for exception to the Standard design criteria shall be accompanied by an energy analysis, as specified in Section 402. The report shall provide technical detail on the alternative building and system designs and on the data employed in and resulting from the comparative analysis to verify that both the analysis and the designs meet the criteria of Sections 402 and 403. The energy derived from renewable energy sources shall be clearly identified in the report.~~

~~The energy derived from renewable sources and the reduction in conventional energy requirements derived from nocturnal cooling shall be separately identified from the overall building energy use. Supporting documentation on the basis of the performance estimates for the aforementioned renewable energy sources or nocturnal cooling means must be submitted.~~

~~Energy usage must be calculated in accordance with the design conditions and methods specified in this code.~~

Exception: ~~Proposed alternative designs for buildings of less than 20,000 square feet (1858 m²) of conditioned floor area that derive a minimum of 30 percent of their total annual energy usage from renewable sources or from nocturnal cooling shall be exempt from the requirement of a full-year energy system analysis.~~

CHAPTER 5

RESIDENTIAL BUILDING DESIGN BY COMPONENT PERFORMANCE APPROACH

502.1.1 ~~Reserved~~ Moisture control. ~~The design shall not create conditions of accelerated deterioration from moisture condensation. Frame walls, floors and ceilings not ventilated to allow moisture to escape shall be provided with an approved vapor retarder having a maximum permeance rating of 1.0 perm (5.72×10^{-9} g/Pa \times s \times m²) when tested in accordance with Procedure A of ASTM E 96. The vapor retarder shall be installed on the warm-in-winter side of the thermal insulation.~~

Exceptions:

- ~~1. In construction where moisture or its freezing will not damage the materials.~~
- ~~2. Where the county in which the building is being constructed is considered a hot and humid climate area and identified as such in Figures 302.1(1) through 302.1(51).~~
- ~~3. Where other approved means to avoid condensation in unventilated framed wall, floor, roof and ceiling cavities are provided.~~

Since a vapor retarder is not required in hot and humid climates, removing the language prevents confusion.

502.1.3 Recessed lighting fixtures. When installed in the building envelope, recessed lighting fixtures shall meet one of the following requirements:

1. Type IC rated, manufactured with no penetrations between the inside of the recessed fixture and ceiling cavity and sealed or gasketed to prevent air leakage into the unconditioned space.
2. Type IC or non-IC rated, installed inside a sealed box constructed from a minimum 0.5-inch-thick (12.7 mm) gypsum wallboard or constructed from a pre-formed polymeric vapor barrier, or other air-tight assembly manufactured for this purpose, while maintaining required clearances of not less than ~~0.5~~ 1-inch-~~(12.7~~ 25mm) from combustible material and not less than 3 inches (76 mm) from insulation material.
3. Type IC rated, in accordance with ASTM E 283 no more than 2.0 cubic feet per minute (cfm) (0.944 L/s) air movement from the conditioned space to the ceiling cavity. The lighting fixture shall be tested at 1.57 psi (75 Pa) pressure difference and shall be labeled.

Increasing the minimum clearance from 1/2" to 1" conforms with local requirements.

502.1.5 Fenestration solar heat gain coefficient. ~~In locations with heating degree days (HDD) less than 3,500,~~ ~~t~~ The combined solar heat gain coefficient (the area-weighted average) of all glazed fenestration products (including the effects of any permanent exterior solar shading devices) in the building shall not exceed 0.40.

Exceptions:

1. Any glazing facing within 45 degrees of true north;
2. Any glazing facing within 45 degrees of true south which is shaded along its full width by a permanent overhang with a projection factor of 0.3 or greater.
3. Any fenestration with attached screens where the screens have a rated shading coefficient of 0.6 or less.

1. *Simplifies the section by eliminating reference to HDD.*

2. *The exceptions will allow north facing windows, which do not receive direct solar radiation, to be exempt from the minimum SHGC requirement; provides a simple way for south facing windows to effectively achieve summer shade and still receive some solar heat benefit in winter; and specifically allows use of solar screens as one method to achieve the shading effect.*

502.2 Heating and cooling criteria. The building envelope shall meet the provisions of Table 502.2. Compliance shall be demonstrated in accordance with Section 502.2.1, 502.2.2, 502.2.3, 502.2.4 or 502.2.5; as applicable. Energy measure trade-offs utilizing equipment ~~meeting~~ exceeding the requirements of Section 503, 504, or 505 shall only use the compliance method described in Chapter 4.

TABLE 502.2 *
HEATING AND COOLING CRITERIA

ELEMENT	MODE	TYPE A-1 RESIDENTIAL BUILDINGS	TYPE A-2 RESIDENTIAL BUILDINGS
		U_o	U_o
Walls	Heating or cooling	<u>0.219</u>	<u>0.323</u>
Roof/ceiling	Heating or cooling	<u>0.0423</u>	<u>0.0423</u>
Floors over unheated spaces	Heating or cooling	<u>0.07</u>	<u>0.07</u>
Heated slab on grade ^{b,f,g}	Heating	R-value = <u>6</u>	R-value = <u>6</u>

Unheated slab on grade ^{c,d,f a}	Heating	R-value = <u>none required</u>	R-value = <u>none required</u>
Basement wall ^{c,f b,c}	Heating or cooling	U-factor = <u>none required</u>	U-factor = <u>none required</u>
Crawl space wall ^{c,f b,c}	Heating or cooling	U-factor = <u>0.15</u>	U-factor = <u>0.15</u>

For SI: 1 Btu/h × ft 2 × °F = 5.678 W/(m 2 × K), °C = [(°F)-32]/1.8.

- a. Values shall be determined by using the graphs [Figures 502.2(1), 502.2(2), 502.2(3), 502.2(4), 502.2(5) and 502.2(6)] using HDD as specified in Section 302.
- b. There are no insulation requirements for heated slabs in locations having less than 500 Fahrenheit HDD.
- c. There are no insulation requirements for unheated slabs in locations having less than 2,500 Fahrenheit HDD.
- d a. Slab edge insulation is not required for unheated slabs in areas of very heavy termite infestation probability in accordance with Section 502.2.1.4, and as shown in Figure 502.2(7).
- e b. Basement and crawl space wall U-factors shall be based on the wall components and surface air films. Adjacent soil shall not be considered in the determination of the U-factor.
- f c. Typical foundation insulation techniques can be found in the DOE *Building Foundation Design Handbook*.

Simplifies the table by inserting values from Figures 502.2(1) - (6) for Houston's established HDD thus eliminating the need for the first 3 footnotes.

502.2.1.2 Roof/ceiling. The combined thermal transmittance value (U_o) of the gross area of the roof or ceiling assembly shall not exceed the value given in Table 502.2. Equation 5-5 shall be used to determine acceptable combinations to meet this requirement. Skylight shafts, 12 inches (305 mm) in depth and greater, shall be insulated to no less than R-13 in climates 0-4,000 HDD and R-19 in climates greater than 4,000 HDD. The skylight shaft thermal performance shall not be included in the roof thermal transmission coefficient calculation.

$$U_o = \frac{(U_R \times A_R) + (U_S \times A_S)}{A_o} \quad \text{(Equation 5-5)}$$

where:

U_o = The average thermal transmittance of the gross roof/ceiling area.

A_o = The gross area of the roof/ceiling assembly.

U_R = The combined thermal transmittance of the various paths of heat transfer through the opaque roof/ceiling area.

A_R = Opaque roof/ceiling assembly area.

U_s = The combined thermal transmittance of the area of all skylight elements in the roof/ceiling assembly.

A_s = The area (including frame) of all skylights in the roof/ceiling assembly.

Notes: (1) When more than one type of roof/ceiling and/or skylight is used, the U and A terms for those items shall be expanded into their subelements as:

$(U_{R1} \times A_{R1}) + (U_{R2} \times A_{R2}) + \dots$ etc. **(Equation 5-6)**

(2) Access doors or hatches in a roof/ceiling assembly shall be included as a subelement of the roof/ceiling assembly.

502.2.1.2.1 Skylights. Skylight shafts, 12 inches (305 mm) in depth and greater, shall be insulated to no less than R-13 in climates 0-4,000 HDD and R-19 in climates greater than 4,000 HDD. The skylight shaft thermal performance shall not be included in the roof thermal transmission coefficient calculation.

Simplifies understanding the requirement by deleting reference to other climates.

502.2.1.4 Slab-on-grade floors. Reserved The thermal resistance of the insulation around the perimeter of the floor shall not be less than the value given in Table 502.2. Where insulation is not required in accordance with Footnote d to Table 502.2, building envelope compliance shall be demonstrated by (a) using Section 502.2.2 or Chapter 4 with the actual slab insulation R-value in Table 502.2 or (b) using Section 502.2.4. Insulation shall be of an approved type, and placed on the outside of the foundation or on the inside of a foundation wall. In climates below 6,000 annual Fahrenheit HDD, the insulation shall extend downward from the elevation of the top of the slab for a minimum distance of 24 inches (610 mm) or downward to at least the bottom of the slab and then horizontally to the interior or exterior for a minimum total distance of 24 inches (610 mm). In all climates equal to or greater than 6,000 HDD, the insulation shall extend downward from the elevation of the top of the slab for a minimum of 48 inches (1219 mm) or downward to at least the bottom of the slab and then horizontally to the interior or exterior for a minimum total distance of 48 inches (1219 mm). In all climates, horizontal insulation extending outside of the foundation shall be covered by pavement or by soil a minimum of 10 inches (254 mm) thick. The top edge of the insulation installed between the exterior wall and the edge of the interior slab shall be permitted to be cut at a 45-degree angle away from the exterior wall.

Houston is an area with heavy termite infestation. The section is not applicable and can be confusing to users of the code.

502.2.1.5 Crawl space walls. If the floor above a crawl space does not meet the requirements of Section 502.2.1.3 and the crawl space does not have ventilation openings which communicate directly with outside air, then the exterior walls of the crawl space shall have a thermal transmittance value not exceeding the value given in Table 502.2. Where the inside ground surface is less than 12 inches (305 mm) or greater below the outside finish ground level or the vertical wall insulation stops less than 12 inches (305 mm) below the

outside finish ground level, crawl space wall insulation shall extend vertically and horizontally a minimum total distance of 24 inches (610 mm) linearly from the outside finish ground level [see Appendix Details 502.2.1.5(1), 502.2.1.5(2) and 502.2.1.5(3) and the DOE *Foundation Design Handbook*]. Where the inside ground surface is less than 12 inches (305 mm) below the outside finish ground level, insulation shall extend from the top of the crawl space wall to the top of the footing [See Appendix Detail 502.2.1.5(2) and the DOE Foundation Design Handbook].

502.2.2 Compliance by total building envelope performance. The building envelope design of a proposed building shall be permitted to deviate from the U_o -factors, U-factors, or R-values specified in Table 502.2, provided the total thermal transmission heat gain or loss for the proposed building envelope does not exceed the total heat gain or loss resulting from the proposed building's conformance to the values specified in Table 502.2. For basement and crawl space walls that are part of the building envelope, the U-factor of the proposed foundation shall be adjusted by the R-value of the adjacent soil where the corresponding U-factor in Table 502.2 is similarly adjusted. Heat gain or loss calculations for slab edge and basement or crawl space wall foundations shall be determined using methods consistent with the ASHRAE *Handbook of Fundamentals*.

Language deleted because there is no R-value requirement for the basement wall in zone 3.

502.2.3.4 Slab-on-grade floors. Slab-on-grade floors shall meet the provisions of Table 502.2, as determined by Section 502.2.1.4.

Reference to a deleted section.

502.2.3.5 Crawl space walls. ~~Where~~ If the floor above a crawl space does not meet the requirements of Section 502.2.3.3 and the crawl space does not have ventilation openings that communicate directly with outside air, then the exterior walls of the crawl space shall have a thermal transmittance value not exceeding the value given in Table 502.2. The U-factor of the exterior crawl space wall shall be determined by selecting the U-factor for the appropriate crawl space wall section from Appendix Table 502.2.3.5. ~~Where the inside ground surface is less than 12 inches (305 mm) or greater below the outside finish ground level or the vertical wall insulation stops less than 12 inches (305 mm) below the outside finish ground level, crawl space wall~~ insulation shall extend vertically and horizontally a minimum total distance of 24 inches (610 mm) linearly from the outside finish ground level from the top of the wall to at least the inside ground surface [see Appendix Details 502.2.1.5(1), 502.2.1.5(2) and 502.2.1.5(3) and the DOE Building Foundation Design Handbook]. Where the inside ground surface is less than 12 inches (305 mm) below the outside finish ground level, insulation shall extend from the top of the crawl space wall to the top of the footing [See Appendix Detail 502.2.1.5(2) and the DOE Foundation Design Handbook].

Delete Tables 502.2.4 (1-6) and replace with the following:

TABLE 502.2.4(1)

PRESCRIPTIVE BUILDING ENVELOPE REQUIREMENTS, TYPE A-1 RESIDENTIAL BUILDINGS, BASED ON WINDOW AREA AS A PERCENT OF GROSS EXTERIOR WALL AREA

% Glazing	Maximum	Minimum					
	Glazing U-factor	Ceiling R-value	Exterior wall R-value	Floor R-value	Basement wall R-value	Slab perimeter R-value	Crawl space wall R-value
< 8%	Any	R-19	R-11	R-11	R-0	R-0	R-5
< 12%	0.75	R-19	R-11	R-11	R-0	R-0	R-5
< 15%	0.75	R-19	R-11	R-11	R-0	R-0	R-5
< 18%	0.70	R-26	R-13	R-11	R-0	R-0	R-5
< 20%	0.70	R-30	R-13	R-11	R-0	R-0	R-5
< 25%	0.55	R-30	R-13	R-11	R-0	R-0	R-5

Replace Tables 502.2.4 (7-9) and replace with the following.

TABLE 502.2.4(2)

PRESCRIPTIVE BUILDING ENVELOPE REQUIREMENTS, TYPE A-2 RESIDENTIAL BUILDINGS, BASED ON WINDOW AREA AS A PERCENT OF GROSS EXTERIOR WALL AREA

% Glazing	Maximum	Minimum					
	Glazing U-factor	Ceiling R-value	Exterior wall R-value	Floor R-value	Basement wall R-value	Slab perimeter R-value	Crawl space wall R-value
≤ 20%	Any	R-19	R-11	R-11	R-5	R-0	R-5
≤ 25%	Any	R-19	R-11	R-11	R-0	R-0	R-5
≤ 30%	0.70	R-19	R-11	R-11	R-0	R-0	R-4

Reduces the number of tables to be referenced.

502.2.5 Prescriptive path for additions and window replacements. As an alternative to demonstrating compliance with Section 402 or 502.2, additions with a conditioned floor area less than 500 square feet (46.5 m²) to existing single-family residential buildings and structures shall meet the prescriptive envelope component criteria in Table 502.2.5 for the designated heating degree days (HDD) applicable to the location. The U-factor of each individual fenestration product (windows, doors and skylights) shall be used to calculate an area-weighted average fenestration product U-factor for the addition, which shall not exceed the applicable listed values in Table 502.2.5. For additions, the total area of fenestration products shall not exceed 40 percent of the gross wall and roof area of the addition. The R-values for opaque thermal envelope components shall be equal to or greater than the applicable listed values in Table 502.2.5. Replacement fenestration products (where the entire unit, including the frame, sash and glazing, is replaced) shall meet the prescriptive fenestration U-factor criteria in Table 502.2.5 for the designated HDD applicable to the location. Conditioned sunroom additions shall be served by a separate heating or cooling system, or shall be controlled as separate zone of the existing system. Fenestration products used in additions and as replacement windows in accordance with this section shall also meet the requirements of Section 502.1.5 in locations with HDD less than 3,500.

Exception: Replacement skylights shall have a maximum U-factor of 0.50 when installed in any location above 1,999 HDD.

Exception not applicable in Houston

TABLE 502.2.5

PRESCRIPTIVE ENVELOPE COMPONENT CRITERIA ADDITIONS TO AND REPLACEMENT WINDOWS FOR EXISTING SINGLE-FAMILY RESIDENTIAL BUILDINGS

HEATING DEGREE DAYS	MAXIMUM	MINIMUM					
	Fenestration U-factor ^a	Ceiling R- value	Wall R-value	Floor R- value	Basement wall R-value ^b	Slab Perimeter R- value and Depth ^c	Crawl Space Wall R-value ^d
0-1,999	0.75	R-26	R-13	R-11	R-5	R-0	R-5
2,000-3,999	0.5	R-30	R-13	R-19	R-8	R-5, 2 ft.	R-10
4,000-5,999	0.4	R-38	R-18	R-21	R-10	R-9, 2 ft.	R-19
6,000-8,499	0.35	R-49	R-21	R-21	R-11	R-13, 4 ft.	R-20
8,500-12,999	0.35	R-49	R-21	R-21	R-19	R-18, 4 ft.	R-20

For SI: 1 foot = 304.8 mm.

- a. "Ceiling *R*-value" shall be required for flat or inclined (cathedral) ceilings. Floors over outside air shall meet "Ceiling *R*-value" requirements.
- b. Basement wall insulation shall be installed in accordance with Section 502.2.1.6.
- c. Slab perimeter insulation shall be installed in accordance with Section 502.2.1.4. An additional R-2 shall be added to "Slab perimeter *R*-value" in the table if the slab is heated.
- d. "Crawl space wall *R*-value" shall apply to unventilated crawl spaces only. Crawl space insulation shall be installed in accordance with Section 502.2.1.5.
- e. Sunroom additions shall be required to have a minimum *U*-factor of 0.50 in locations $\geq 2,000$ HDD.

This U-factor for sunrooms will be required in Houston increasing the stringency of the code in order to compensate for window SHGC exceptions

503.1 General. This section covers mechanical systems and equipment used to provide heating, ventilating and air-conditioning functions. This section assumes that residential buildings and dwelling units therein will be designed with individual HVAC systems. Where equipment not shown in Table 503.2 is specified, it shall meet the provisions of Section 803.2.2 and 803.3.2. ~~403 of ASHRAE/IES Energy Code for Commercial and High-Rise Residential Buildings.~~

TABLE 503.2
MINIMUM EQUIPMENT PERFORMANCE

EQUIPMENT CATEGORY	SUB-CATEGORY ^a	REFERENCED STANDARD	MINIMUM PERFORMANCE
Air-cooled heat pumps heating mode < 65,000 Btu/h cooling capacity	Split systems Single package	ARI 210/240	6.8 HSPF ^{a,b} 6.6 HSPF ^{a,b}
Gas-fired or oil-fired furnace <225,000 Btu/h	-----	DOE 10 CFR Part 430, Subpart B, Appendix N	AFUE 78 80 % ^b <i>E t</i> 80% ^c
Gas-fired or oil-fired steam and hot-water boilers < 300,000 Btu/h	-----	DOE 10 CFR Part 430, Subpart B, Appendix N	AFUE 80% ^{b,d}
Air-cooled air conditioners and heat pumps cooling mode < 65,000 Btu/h cooling capacity	Split systems Single package	ARI 210/240	10.0 SEER ^b 9.7 EER ^b

For SI: 1 Btu/h = 0.2931 W.

- a. For multicapacity equipment, the minimum performance shall apply to each capacity step provided. Multicapacity refers to manufacturer-published ratings for more than one capacity mode allowed by the product's controls.
- b. This is used to be consistent with the National Appliance Energy Conservation Act (NAECA) of 1987 (Public Law 100-12).
- c. These requirements apply to combination units not covered by NAECA (three-phase power or cooling capacity 65,000 Btu/h).
- d. Except for gas-fired steam boilers for which minimum AFUE shall be 75% percent.
- e. Seasonal rating.

Increased AFUE is standard and more stringent than unamended code.

503.3.1 Load calculations. Heating and cooling system design loads for the purpose of sizing systems and equipment shall be determined ~~in accordance with the procedures described in the ASHRAE Handbook of Fundamentals or an equivalent computation procedure,~~ using the design parameters specified in Chapter 3.

Base code does not call for these to be submitted. The City does not review these calculations. Further, the calculation methods are ambiguous. There is no consensus as to the calculation methods to be used even within ASHRAE.

503.3.2.2 Thermostatic control capabilities. Where used to control comfort heating, thermostatic controls shall be capable of being set locally or remotely by adjustment or selection of sensors down to 55°F (13°C) or lower.

Where used to control comfort cooling, thermostatic controls shall be capable of being set locally or remotely by adjustment or selection of sensors up to 85°F (29°C) or higher.

Where used to control both comfort heating and cooling, thermostatic controls shall be capable of providing a temperature range or dead band of at least 5-3°F ($\Delta 3 \pm 2^\circ\text{C}$) within which the supply of heating and cooling energy is shut off or reduced to a minimum.

Exceptions:

1. Special occupancy or special usage conditions approved by the code official.
2. Thermostats that require manual changeover between heating and cooling modes.

A 5 degree dead band does not make sense in the Houston climate where dehumidification is of paramount importance to reduce mold. The engineering community designs with a 3 degree dead band standard.

503.3.2.3 Heat pump auxiliary heat. Heat pumps having supplementary electric resistance heaters shall have controls that prevent heater operation when the heating load is capable of being met by the heat pump. Supplemental heater operation is not allowed except during out-door coil defrost cycles not exceeding 15 minutes.

Heat pumps are manufactured to be "smart" so the supplemental heater stops defrosting when the condenser warms up, usually in much less time than 15 minutes. Manufacturers do not build heat pumps to limit the defrost cycle to a certain number of minutes and so this requirement specifies equipment that is not on the market.

503.3.2.4 Humidistat. ~~Humidistats used for comfort purposes shall be capable of being set to prevent the use of fossil fuel or electricity to reduce relative humidity below 60 percent or increase relative humidity above 30 percent.~~

Greatly increases the probable formation of mold in a hot and humid climate.

TABLE 503.3.3.1
MINIMUM PIPE INSULATION
(thickness in inches)

PIPING SYSTEM TYPES	FLUID TEMPERATURE RANGE, °F	Pipe Sizes ^{a, c}					
		Runouts up to 2" ^b	1 and less	1.25" to 2"	2.5" to 4"	5" to 6"	8" and larger
HEATING SYSTEMS							
Steam and hot water:							
High pressure/temperature	306-450	1 ½	2 ½	2 ½	3	3 ½	3 ½
Medium pressure/temperature	251-305	1 ½	2	2 ½	2 ½	3	3
Low pressure/temperature	201-250	1	1 ½	1 ½	2	2	2
Low temperature	106 120-200	½	1	1	1 ½	1 ½	1 ½
Steam condensate (for feed water)	Any	1	1	1 ½	2	2	2
COOLING SYSTEMS							
Chilled water, refrigerant and brine:	40-55	½	½	¾	1	1	1
	Below 40	1	1	1 ½	1 ½	1 ½	1 1/2

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, °C = [(°F)-32]/1.8.

- a. For piping exposed to outdoor air, increase insulation thickness by 0.5 inch.
- b. Runouts not exceeding 12 feet in length to individual terminal units.
- c. Inside pipe diameter.

Clarifies the measurement for consistency.

Delete table 503.3.3.3 and substitute with table below

TABLE 503.3.3.3
MINIMUM DUCT INSULATION^a

Annual Heating Degree Days	Insulation R-value (h • ft ² • °F)/Btu ^d			
	Ducts in unconditioned attics or outside building		Ducts in unconditioned basements, crawl spaces, garages, and other unconditioned spaces ^c	
	Supply	Return	Supply	Return
Below 1,500	8 6	4 6	4 6	0 6
1,500 to 3,500	8	4	6	2
3,501 to 7,500	8	4	8	2
Above 7,500	11	6	11	2

- a. Insulation R-values shown are for the insulation as installed and do not include film resistance. The required minimum R-values do not consider water vapor transmission and condensation. Where control of condensation is required, additional insulation, vapor retarders, or both, shall be provided to limit vapor transmission and condensation. For ducts that are designed to convey both heated and cooled air, duct insulation shall be as required by the most restrictive condition. Where exterior walls are used as plenums, wall insulation shall be as required by the most restrictive condition of this section.
- b. Insulation on return ducts in basements is not required.
- c. Unconditioned spaces include ventilated crawl spaces, ventilated attics and framed cavities for those floor, wall and ceiling assemblies which (1) separate conditioned space from unconditioned space or outside air, and (2) are uninsulated on the side facing away from the conditioned space.
- d. Insulation resistance measured on a horizontal plane in accordance with ASTM C 518, at a mean temperature of 75°F.

Insulation requirements are adjusted to R-6 for all supply and return duct insulation in Houston. The increase from R-4 to R-6 for outside return ducts and for supply ducts in unconditioned spaces and from R-0 to R-6 for return ducts in unconditioned spaces balances out the reduction from R-8 to R-6 for outside supply.

503.3.3.4.1 High- and medium-pressure duct systems. High-pressure and medium-pressure ducts shall be leak tested in accordance with the SMACNA *HVAC Air Duct Leakage Test Manual* with the rate of air leakage not to exceed the maximum rate specified in that standard.

All ducts and plenums operating at static pressures greater than 2 in. w.g. (500 Pa) shall be insulated and sealed in accordance with Section 803.2.8. Ducts operating at static pressures greater than 3 in. w.g. (750 Pa) shall be leak tested in accordance with Section 803.3.6. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the International Mechanical Code.

503.3.3.4.2 Low-pressure duct systems. All longitudinal and transverse joints, seams and connections of low-pressure supply and return ducts shall be securely fastened and sealed with welds, gaskets, mastics

(adhesives), mastic-plus-embedded-fabric systems or tapes installed in accordance with the manufacturer's installation instructions.

503.3.3.4.2 Low-pressure duct systems. All longitudinal and transverse joints, seams and connections of supply and return ducts operating at static pressures less than or equal to 2 in. w.g. (500 Pa) shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems or tapes installed in accordance with the manufacturer's installation instructions. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the International Mechanical Code.

Exception: Continuously welded and locking-type longitudinal joints and seams on ducts operating at static pressures less than 2 inches w.g. (500 Pa) pressure classification.

503.3.3.4.3 Sealing required. Tapes and mastics used with rigid fibrous glass ducts shall be listed and labeled in accordance with UL 181A. Tapes and mastics used with flexible air ducts shall be listed and labeled in accordance with UL 181B. "Duct tape" is not permitted as a sealant on any ducts. Sealing shall be as required in the *Mechanical Code*.

Houston Mechanical Code sealing requirements (attached) significantly exceed the IECC and IMC requirements.

CHAPTER 6

SIMPLIFIED PRESCRIPTIVE REQUIREMENTS FOR RESIDENTIAL BUILDINGS, TYPE A-1 AND A-2

602.1.6 Slab-on-grade floors. For slabs with a top edge 12 inches (305 mm) or less below finished grade, the required “Slab perimeter R-value and depth” ~~shall not be required. in Table 602.1 shall be applied to the outside of the foundation or the inside of the foundation wall.~~ The insulation shall extend downward from the top of the slab or downward from the top of the slab to the bottom of the slab and then horizontally to the interior or exterior, until the distance listed in Table 602.1 is reached.

~~Where installed between the exterior wall and the edge of the interior slab, the top edge of the insulation shall be permitted to be cut at a 45-degree (0.79 rad) angle away from the exterior wall. Insulation extending horizontally outside of the foundation shall be protected by pavement or by a minimum of 10 inches (254 mm) of soil.~~

~~In locations of 500 HDD or greater, R-2~~ Insulation with a value of R-12 shall be added to the “Slab perimeter R-value” in Table 602.1 where uninsulated hot water pipes, air distribution ducts, or electric heating cables are installed within or under the slab.

Exception: Slab perimeter insulation is not required for unheated slabs in areas of very heavy termite infestation probability as shown in Figure 502.2(7). Where this exception is used, building envelope compliance shall be demonstrated by (a) using Section 502.2.2 or Chapter 4 with the actual “Slab perimeter R-value and depth” in Table 602.1, or (b) using Section 502.2.4.

Clarifies that slab perimeter insulation is not required for unheated slabs in areas of heavy termite infestation.

602.1.10 Caulking, sealants and gasketing. All joints, seams, penetrations (site-built windows, doors, and skylights), openings between window and door assemblies and their respective jambs and framing, and other sources of air leakage (infiltration and exfiltration) through the building envelope shall be caulked, gasketed, weatherstripped, wrapped, or otherwise sealed ~~to limit uncontrolled air movement. with systems compatible with the construction material and location.~~ Joints and seams shall be sealed in the same manner or taped or covered with a moisture vapor-permeable wrapping material. Sealing materials and combinations of materials shall allow for expansion and contraction of all the construction materials.

This language is more specific to preclude inadequate sealing.

602.2 Maximum solar heat gain coefficient for fenestration products. ~~In locations with heating degree days (HDD) less than 3,500, t~~ The area-weighted-average solar heat gain coefficient (SHGC) for glazed fenestration installed in the building envelope shall not exceed 0.40.

Exceptions:

1. Any glazing facing within 45 degrees of true north;
2. Any glazing facing within 45 degrees of true south which is shaded along its full width by a permanent overhang with a projection factor of 0.3 or greater.
3. Any fenestration with attached screens where the screens have a rated shading coefficient of 0.6 or less.

1. Simplifies the section by eliminating reference to HDD.

2. The exceptions will allow north facing windows, which do not receive direct solar radiation, to be exempt from the minimum SHGC requirement; provides a simple way for south facing windows to effectively achieve summer shade and still receive some solar heat benefit in winter; and specifically allows use of solar screens as one method to achieve the shading effect.

CHAPTER 7

BUILDING DESIGN FOR ALL COMMERCIAL BUILDINGS

701.1 General. Commercial buildings shall meet the requirements of ASHRAE/IES 90.1 Energy Code for Commercial and High-Rise Residential Buildings.

Exception: Commercial buildings that comply with Chapter 8.

CHAPTER 8

DESIGN BY ACCEPTABLE PRACTICE FOR COMMERCIAL BUILDINGS

801.2 Application. The requirements in Sections 802, 803, 804 and 805 shall each be satisfied on an individual basis. Where one or more of these sections is not satisfied, compliance for that section(s) shall be demonstrated in accordance with the applicable provisions of ASHRAE/IESNA 90.1. *Energy Code for Commercial and High-Rise Residential Buildings.*

Exception: Buildings meeting Section 806 provided Sections 802.1.2, 802.3, 803.2.1 or 803.3.1 as applicable, 803.2.2 or 803.3.2 as applicable, 803.2.3 or 803.3.3 as applicable, 803.2.8 or 803.3.6 as applicable, 803.2.9 or 803.3.7 as applicable, 804, 805.2, 805.3, and 805.5 are each satisfied.

802.1 General. Walls, roof assemblies, floors, glazing, and slabs on grade which are part of the building envelope for buildings where the window and glazed door area is not greater than 50 percent of the gross area of above-grade walls shall meet the requirements of Sections 802.2.1 through 802.2.8, as applicable. Buildings with more glazing shall meet the applicable provisions of ASHRAE/IES NA 90.1. *Energy Code for Commercial and High-Rise Residential Buildings.*

802.1.2 Reserved. ~~Moisture control. All framed walls, floors, and ceilings not ventilated to allow moisture to escape shall be provided with an approved vapor retarder having a maximum permance rating of 1.0 perm ($5.72 \times 10^{-8} \text{ g/Pa} \times \text{s} \times \text{m}^2$), when tested in accordance with Procedure A of ASTM E 96, on the warm-in-winter side of the insulation.~~

Exceptions:

- ~~1. Buildings located in Climate Zones 1 through 7 as indicated in Table 302.1.~~
- ~~2. In construction where moisture or its freezing will not damage the materials.~~
- ~~3. Where other approved means to avoid condensation in unventilated framed wall, floor, roof and ceiling cavities are provided.~~

Since a vapor retarder is in not required in hot and humid climates, removing the language prevents confusion.

802.2 Criteria. The building envelope components shall meet each of the applicable requirements in Tables 802.2(1), 802.2(2), 802.2(3) and 802.2(4) based on the percentage of wall that is glazed. The percentage of wall that is glazed shall be determined by dividing the aggregate area of rough openings for glazing (windows and glazed doors) in all the above-grade walls associated with the building envelope by the total gross area of all above-grade exterior walls that are a part of the building envelope. In buildings with multiple types of building envelope construction, each building envelope construction type shall be evaluated separately. Where Table 802.2(1), 802.2(2), 802.2(3) or 802.2(4) does not list a particular construction type, the

applicable provisions of ASHRAE/IESNA 90.1, *Energy Code for Commercial and High-Rise Residential Buildings* shall be used in lieu of Section 802.

802.2.1 Above-grade walls. The minimum thermal resistance (R -value) of the insulating material(s) installed in the wall cavity between the framing members and continuously on the walls shall be as specified in Table 802.2(1), 802.2(2), 802.2(3) or 802.2(4), based on framing type and construction materials used in the wall assembly. Where both cavity and continuous insulation values are provided in Table 802.2(1), 802.2(2), 802.2(3) or 802.2(4), both requirements shall be met. Concrete masonry units (CMU) at least 8-inch (203 mm) nominal thickness with essentially equal amounts of mass on either side of the insulation layer are considered as having integral insulation, however, the thermal resistance of that insulation shall not be considered when determining compliance with Table 802.2(1), 802.2(2), 802.2(3) or 802.2(4). "Other masonry walls" shall include walls weighing at least 35 lb/ft² (170 kg/m²) of wall surface area and do not include CMUs less than 8 inches (203 mm) nominal thickness.

Exception: Area-weighted combinations of insulated walls and windows will be acceptable that provide an overall thermal transmittance (R -value) for the composite walls that is equivalent to, or greater than, the corresponding overall R -value of the composite walls as determined by Table 802.2(1), 802.2(2), 802.2(3) or 802.2(4). The applicable table shall be determined by the percentage of glass. For equivalency calculations, the equation $U = 1/R$ shall be used, such that:

$$[(A_{w1} \times R_{w1}) + (A_{g1} \times (1/U_{g1}))] \leq [(A_{w*} \times R_{w*}) + (A_{g*} \times (1/U_{g*}))]$$

where:

A_{w1} = Area of the insulated walls

R_{w1} = R - value for the insulated walls, as required by Table 802.2(1), 802.2(2), 802.2(3) or 802.2(4)

A_{g1} = Area of the glass

U_{g1} = U -factor for the glass, as required by Table 802.2(1), 802.2(2), 802.2(3) or 802.2(4)

A_{w*} = Area of the proposed insulated wall whose thermal resistance is R_{w*}

R_{w*} = R -value for the proposed insulated wall

A_{g*} = Area of the proposed glass

U_{g*} = U -factor for the proposed glass

An area weighted average combining the wall R -values and glazing U -factors provides an equivalent alternative.

TABLE 802.2(1)
BUILDING ENVELOPE REQUIREMENTS^{a through e}
WINDOW AND GLAZED DOOR AREA 10 PERCENT OR LESS OF ABOVE GRADE WALL AREA

ELEMENT	CONDITION/VALUE		
Skylights (<i>U</i> -factor)	<u>1</u>		
Slab or below-grade wall (<i>R</i> -value)	<u>R-0</u>		
Windows and glass doors PF < 0.25 0.25 ≤ PF < 0.50 PF ≥ 0.50	SHGC	<i>U</i>-factor	
	<u>Any</u>	<u>Any</u>	
	<u>Any</u>	<u>Any</u>	
	<u>Any</u>	<u>Any</u>	
Roof assemblies (<i>R</i> -value) All-wood joist/truss Metal joist/truss Concrete slab or deck Metal purlin with thermal block Metal purlin without thermal block	Insulation between framing	Continuous insulation	
	<u>R-19</u>	<u>R-12</u>	
	<u>R-19</u>	<u>R-13</u>	
	<u>NA</u>	<u>R-12</u>	
	<u>R-19</u>	<u>R-13</u>	
	<u>R-30</u>	<u>R-13</u>	
Floors over outdoor air or unconditioned space (<i>R</i> -value) All wood joist/truss Metal joist/truss Concrete slab or deck	Insulation between framing	Continuous insulation	
	<u>R-11</u>	<u>R-4</u>	
	<u>R-11</u>	<u>R-4</u>	
	<u>NA</u>	<u>R-2</u>	
Above-grade walls (<i>R</i> -value) Framed R-value cavity R-value continuous CMU, ≥8 in, with integral insulation R- value cavity R- value continuous Other masonry walls R-value cavity R-value continuous	No framing	Metal framing	Wood framing
	NA	<u>R-11</u> R-0	<u>R-11</u> R-0
	NA	<u>R-0</u>	<u>R-0</u>
	NA	<u>R-4</u> R-0	<u>R-4</u> R-0
	<u>R-0</u>	<u>R-0</u>	<u>R-0</u>
	NA	<u>R-4</u> R-0	<u>R-4</u> R-0
	<u>R-0</u>	<u>R-0</u>	<u>R-0</u>

For SI: 1 inch = 25.4 mm.

- Values ~~shall be~~ have been determined from Tables 802.2(5) through 802.2(37) using the climate zone(s) specified in Table 302.1. (Note: The tables begin on page 116.)
- "NA" indicates the condition is not applicable.
- An *R*-value of zero indicates no insulation is required.
- "Any" indicates any available product will comply.
- "X" indicates no complying option exists for this condition.

The blanks in these tables were filled from the zone 3b Table 802.2(10). Above-grade wall R-values increased to compare with residential framed walls and to increase stringency of code.

TABLE 802.2(2)
BUILDING ENVELOPE REQUIREMENTS^{a through e}
WINDOW AND GLAZED DOOR AREA OVER 10 PERCENT BUT NOT GREATER THAN 25 PERCENT OF ABOVE GRADE WALL AREA

ELEMENT	CONDITION/VALUE		
Skylights (<i>U</i> -factor)	<u>1</u>		
Slab or below-grade wall (<i>R</i> -value)	<u>R-0</u>		
Windows and glass doors	SHGC	<i>U</i>-factor	
PF < 0.25	<u>0.5</u>	<u>Any</u>	
0.25 ≤ PF < 0.50	<u>0.6</u>	<u>Any</u>	
PF ≥ 0.50	<u>0.7</u>	<u>Any</u>	
Roof assemblies (<i>R</i>-value)	Insulation between framing	Continuous insulation	
All-wood joist/truss	<u>R-19</u>	<u>R-12</u>	
Metal joist/truss	<u>R-19</u>	<u>R-13</u>	
Concrete slab or deck	<u>NA</u>	<u>R-12</u>	
Metal purlin with thermal block	<u>R-19</u>	<u>R-13</u>	
Metal purlin without thermal block	<u>R-30</u>	<u>R-13</u>	
Floors over outdoor air or unconditioned space (<i>R</i>-value)	Insulation between framing	Continuous insulation	
All wood joist/truss	<u>R-11</u>	<u>R-4</u>	
Metal joist/truss	<u>R-11</u>	<u>R-4</u>	
Concrete slab or deck	<u>NA</u>	<u>R-2</u>	
Above-grade walls (<i>R</i>-value)	No framing	Metal framing	Wood framing
Framed R-value cavity	NA	<u>R-11</u> R-0	<u>R-11</u> R-0
R-value continuous	NA	<u>R-0</u>	<u>R-0</u>
CMU, ≥ 8 in, with integral insulation R- value cavity	NA	<u>R-4</u> R-0	<u>R-4</u> R-0
R- value continuous	<u>R-0</u>	<u>R-0</u>	<u>R-0</u>
Other masonry walls R-value cavity	NA	<u>R-4</u> R-0	<u>R-4</u> R-0
R-value continuous	<u>R-0</u>	<u>R-0</u>	<u>R-0</u>

For SI: 1 inch = 25.4 mm.

- Values ~~shall be~~ have been determined from Tables 802.2(5) through 802.2(37) using the climate zone(s) specified in Table 302.1. (Note: The tables begin on page 116.)
- "NA" indicates the condition is not applicable.
- An *R*-value of zero indicates no insulation is required.
- "Any" indicates any available product will comply.
- "X" indicates no complying option exists for this condition.

The blanks in these tables were filled from the zone 3b Table 802.2(10). Above-grade wall R-values increased to compare with residential framed walls and to increase stringency of code.

TABLE 802.2(3)
BUILDING ENVELOPE REQUIREMENTS ^{a through e}
WINDOW AND GLAZED DOOR AREA OVER 25 PERCENT BUT NOT GREATER THAN 40 PERCENT OF ABOVE GRADE WALL AREA

ELEMENT	CONDITION/VALUE		
Skylights (<i>U</i> -factor)	<u>1</u>		
Slab or below-grade wall (<i>R</i> -value)	<u>R-0</u>		
Windows and glass doors	SHGC	<i>U</i>-factor	
PF < 0.25	0.40 <u>0.50</u>	<u>0.7</u>	
0.25 ≤ PF < 0.50	<u>0.5</u>	<u>0.7</u>	
PF ≥ 0.50	<u>0.6</u>	<u>0.7</u>	
Roof assemblies (<i>R</i>-value)	Insulation between framing	Continuous insulation	
All-wood joist/truss	<u>R-19</u>	<u>R-12</u>	
Metal joist/truss	<u>R-19</u>	<u>R-13</u>	
Concrete slab or deck	<u>NA</u>	<u>R-12</u>	
Metal purlin with thermal block	<u>R-19</u>	<u>R-13</u>	
Metal purlin without thermal block	<u>R-30</u>	<u>R-13</u>	
Floors over outdoor air or unconditioned space (<i>R</i>-value)	Insulation between framing	Continuous insulation	
All wood joist/truss	<u>R-11</u>	<u>R-4</u>	
Metal joist/truss	<u>R-11</u>	<u>R-4</u>	
Concrete slab or deck	<u>NA</u>	<u>R-2</u>	
Above-grade walls (<i>R</i>-value)	No framing	Metal framing	Wood framing
Framed R-value cavity	NA	<u>R-11</u> R-0	<u>R-11</u> R-0
R-value continuous	NA	<u>R-0</u>	<u>R-0</u>
CMU, ≥ 8 in, with integral insulation R- value cavity	NA	<u>R-4</u> R-0	<u>R-4</u> R-0
R- value continuous	<u>R-0</u>	<u>R-0</u>	<u>R-0</u>
Other masonry walls R-value cavity	NA	<u>R-4</u> R-0	<u>R-4</u> R-0
R-value continuous	<u>R-0</u>	<u>R-0</u>	<u>R-0</u>

For SI: 1 inch = 25.4 mm.

- Values ~~shall be~~ have been determined from Tables 802.2(5) through 802.2(37) using the climate zone(s) specified in Table 302.1. (Note: The tables begin on page 116.)
- "NA" indicates the condition is not applicable.
- An *R*-value of zero indicates no insulation is required.
- "Any" indicates any available product will comply.
- "X" indicates no complying option exists for this condition.

The blanks in these tables were filled from the zone 3b Table 802.2(10). Above-grade wall R-values increased to compare with residential framed walls and to increase stringency of code.

TABLE 802.2(4)
BUILDING ENVELOPE REQUIREMENTS ^{a through e}
WINDOW AND GLAZED DOOR AREA OVER 40 PERCENT BUT NOT GREATER THAN 50 PERCENT OF ABOVE GRADE WALL AREA

ELEMENT	CONDITION/VALUE		
Skylights (<i>U</i> -factor)	<u>1</u>		
Slab or below-grade wall (<i>R</i> -value)	<u>R-0</u>		
Windows and glass doors	SHGC	<i>U</i>-factor	
PF < 0.25	0.4 <u>0.50</u>	<u>0.7</u>	
0.25 ≤ PF < 0.50	<u>0.5</u>	<u>0.7</u>	
PF ≥ 0.50	<u>0.6</u>	<u>0.7</u>	
Roof assemblies (<i>R</i>-value)	Insulation between framing	Continuous insulation	
All-wood joist/truss	<u>R-19</u>	<u>R-12</u>	
Metal joist/truss	<u>R-19</u>	<u>R-13</u>	
Concrete slab or deck	<u>NA</u>	<u>R-12</u>	
Metal purlin with thermal block	<u>R-19</u>	<u>R-13</u>	
Metal purlin without thermal block	<u>R-30</u>	<u>R-13</u>	
Floors over outdoor air or unconditioned space (<i>R</i>-value)	Insulation between framing	Continuous insulation	
All wood joist/truss	<u>R-11</u>	<u>R-4</u>	
Metal joist/truss	<u>R-11</u>	<u>R-4</u>	
Concrete slab or deck	<u>NA</u>	<u>R-2</u>	
Above-grade walls (<i>R</i>-value)	No framing	Metal framing	Wood framing
Framed R-value cavity	NA	<u>R-11</u> R-0	<u>R-11</u> R-7
R-value continuous	NA	<u>R-0</u>	<u>R-0</u>
CMU, ≥ 8 in, with integral insulation R-value cavity	NA	<u>R-4</u> R-0	<u>R-4</u> R-0
R-value continuous	<u>R-0</u>	<u>R-0</u>	<u>R-0</u>
Other masonry walls R-value cavity	NA	<u>R-4</u> R-0	<u>R-4</u> R-0
R-value continuous	<u>R-0</u>	<u>R-0</u>	<u>R-0</u>

For SI: 1 inch = 25.4 mm.

- Values ~~shall be~~ have been determined from Tables 802.2(5) through 802.2(37) using the climate zone(s) specified in Table 302.1. (Note: The tables begin on page 116.)
- "NA" indicates the condition is not applicable.
- An *R*-value of zero indicates no insulation is required.
- "Any" indicates any available product will comply.
- "X" indicates no complying option exists for this condition.

The blanks in these tables were filled from the zone 3b Table 802.2(10). Above-grade wall R-values increased to compare with residential framed walls and to increase stringency of code.

802.3.2 Sealing of the building envelope. Openings and penetrations in the building envelope shall be sealed with caulking materials or closed with gasketing systems compatible with the construction materials and location. Joints and seams shall be sealed in the same manner or taped or covered with a moisture vapor-permeable wrapping material. Sealing materials spanning joints between construction. All joints, seams, penetrations (site-built windows, doors and skylights), openings between window and door assemblies and their respective heads, jambs and/or sills and framing, and other sources of air leakage (infiltration and exfiltration) through the building envelope shall be caulked, gasketed, weather-stripped, wrapped, or otherwise sealed with systems compatible with the construction material and location. Joints and seams shall be sealed in the same manner or taped or covered with a moisture vapor-permeable wrapping material. Sealing materials and combinations of materials shall allow for expansion and contraction of all the construction materials.

This language is more specific to preclude inadequate sealing.

802.3.3 Dampers integral to the fire protection system. Stair, elevator shaft vents, and other dampers integral to the building envelope shall be equipped with motorized dampers with a maximum leakage rate of 3 cfm/ft² at 1.0 in w.g. (250 Pa) when tested in accordance with AMCA 500. Such dampers shall be closed during normal building operation and shall open as required by fire and smoke detection systems.

Exception: Gravity (non-motorized) dampers are permitted to be used in buildings less than three stories in height above grade.

802.3.4 Loading dock weatherseals. Cargo doors and loading dock doors shall be equipped with weatherseals to restrict infiltration when vehicles are parked in the doorway.

802.3.5 Vestibules. A door that separates conditioned space from the exterior shall be protected with an enclosed vestibule, with all doors opening into and out of the vestibule equipped with self-closing devices. Vestibules shall be designed so that in passing through the vestibule it is not necessary for the interior and exterior doors to open at the same time.

Exceptions:

1. Buildings in Climate Zones 1a through 4b as indicated in Table 302.1.
2. Doors not intended to be used as a building entrance door, such as doors to mechanical or electrical equipment rooms.
3. Doors opening directly from a sleeping unit or dwelling unit.
4. Doors that open directly fro a space less than 3,000 ft² (298 m²) in area.
5. Revolving doors.
6. Doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.

802.3.6 Recessed lighting fixtures. When installed in the building envelope, recessed lighting fixtures shall meet one of the following requirements:

1. Type IC rated, manufactured with no penetrations between the inside of the recessed fixture and ceiling cavity and sealed or gasketed to prevent air leakage into the unconditioned space.
2. Type IC or non-IC rated, installed inside a sealed box constructed from a minimum 0.5 inch thick (12.7 mm) gypsum wallboard or constructed from a preformed polymeric vapor barrier, or other air-tight assembly manufactured for this purpose, while maintaining required clearances of not less than 0.5 inch (12.7 mm) from combustible material and not less than 3 inches (76 mm) from insulation material.
3. Type IC rated, in accordance with ASTM E283 admitting no more than 2.0 cfm (0.944 L/s) of air movement from the conditioned space to the ceiling cavity. The lighting fixture shall be tested at 1.57 lbs./ft² (75 Pa) pressure difference and shall be labeled.

803.2.1 Calculation of heating and cooling loads. Design loads shall be determined in accordance with the procedures described in Chapters 27 and 28 of the ASHRAE *Handbook of Fundamentals* or an approved equivalent computation procedure. Heating and cooling system design loads for the purpose of sizing systems and equipment shall be determined using the design parameters specified in Chapter 3.

803.2.1.1 Equipment and system sizing. Heating and cooling equipment and systems capacity shall not exceed the loads calculated in accordance with Section 803.2.1.

Equipment sizing is not simple. There are many factors that enter into the choice of size beyond the raw calculations. It should be a matter between the owner and the designer of the system. This paragraph is not enforceable.

Per supplement-- Delete Tables 803.2.2(1)-803.2.2(5), and 803.3.2(1)-803.3.2(3) and replace with the following:

TABLE 803.2.2(1)

UNITARY AIR CONDITIONERS AND CONDENSING UNITS. ELECTRICALLY OPERATED. MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY	SUB-CATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY^b	EFFICIENCY AS OF 10/29/2001^b	TEST PROCEDURE^{a,e}

Air conditioners, air cooled	<65,000 Btu/h ^d	Split system	10.0 SEER	10.0 SEER	ARI 210/240
		Single package	9.7 SEER	9.7 SEER	
	≥65,000 Btu/h and <135,000 Btu/h	Split system and single package	8.9 EER^c	10.3 EER ^c	ARI 340/360
	≥135,000 Btu/h and <240,000 Btu/h	Split system and single package	8.5 EER^c	9.7 EER ^c	
	≥240,000 Btu/h and <760,000 Btu/h	Split system and single package	8.5 EER^c 7.5 IPLV^c	9.5 EER ^c 9.7 IPLV ^c	
	≥760,000 Btu/h	Split system and single package	8.2 EER^c 7.5 IPLV^c	9.2 EER ^c 9.4 IPLV ^c	
Air conditioners, water and evaporatively cooled	<65,000 Btu/h	Split system and single package	9.3 EER	12.1 EER	ARI 210/2400
	≥65,000 Btu/h and <135,000 Btu/h	Split system and single package	10.5 EER^c	11.5 EER ^c	ARI 340/360
	≥135,000 Btu/h and <240,000 Btu/h	Split system and single package	9.6 EER^c	11.0 EER ^c	
	≥240,000 Btu/h	Split system and single package	9.6 EER^c 9.0 IPLV^c	11.0 EER ^c 10.3 IPLV ^c	

For SI: 1 Btu/hr = 0.2931 W

- a. Chapter 9 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
- b. IPLVs are only applicable to equipment with capacity modulation.
- c. Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat.
- d. Single-phase air-cooled air-conditioners < 65,000 Btu/h are regulated by the National Appliance Energy Conservation Act of 1987 (NAECA). SEER values are those set by NAECA.

Eliminates old minimum efficiency column to eliminate confusion.

TABLE 803.2.2(2)

UNITARY AND APPLIED HEAT PUMPS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY	SUB-CATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY^b	EFFICIENCY AS OF 10/29/2001^b	TEST PROCEDURE^a
Air cooled, (cooling mode)	< 65,000 Btu/h ^d	Split system	10.0 SEER	10.0 SEER	ARI 210/240
		Single package	9.7 SEER	9.7 SEER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	Split system and single package	8.9 EER^c	10.1 EER^c	ARI 340/360
	≥ 135,000 Btu/h and < 240,000	Split system and single package	8.5 EER^c	9.3 EER^c	
	≥ 240,000 Btu/h	Split system and single package	8.5 EER^c 7.5 IPLV^c	9.0 EER^c 9.2 IPLV^c	
Water-source (cooling mode)	< 17,000 Btu/h	85°F entering water	9.3 EER	9.3 EER	ARI 320
		86°F entering water		11.2 EER	ISO-13256-1
	≥ 17,000 Btu/h and < 65,000 Btu/h	85°F entering water	9.3 EER	9.3 EER	ARI 320
		86°F entering water		12.0 EER	ISO-13256-1
	≥ 65,000 Btu/h and < 135,000	85°F entering water	10.5 EER	10.5 EER	ARI 320
		86°F entering water		12.0 EER	ISO-13256-1
Groundwater-source (cooling mode)	< 135,000 Btu/h	70°F entering water	11.0 EER	11.0 EER	ARI 325
		50°F entering water	11.5 EER	11.5 EER	ISO-13256-1
		59°F entering water		16.2 EER	
Ground source (cooling mode)	< 135,000 Btu/h	70°F entering brine	10.0 EER	10.0 EER	ARI 330
		70°F entering brine	10.4 EER	10.4 EER	ISO-13256-1
		77°F entering water		13.4 EER	
Air cooled (heating mode)	< 65,000 Btu/h ^d cooling capacity	Split system	6.8 HSPF	6.8 HSPF	ARI 210/240
		Single package	6.6 HSPF	6.6 HSPF	
	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)	47°F db/43°F wb outdoor air	3.0 COP	3.2 COP	ARI 340/360
	> 135,000 Btu/h (cooling capacity)	47°F db/43°F wb outdoor air	2.9 COP	3.1 COP	
Water-source (heating mode)	< 135,000 Btu/h (ooling capacity)	70°F entering water	3.8 COP	3.8 COP	ARI 320

		<u>68°F entering water</u>		<u>4.2 COP</u>	<u>ISO-13256-1</u>
<u>Groundwater-source</u> <u>(heating mode)</u>	<u>< 135,000 Btu/h</u> <u>(cooling capacity)</u>	<u>70°F entering water</u>	<u>3.4 COP</u>	<u>3.4 COP</u>	<u>ARI 325</u>
		<u>50°F entering water</u>	<u>3.0 COP</u>	<u>3.0 COP</u>	
		<u>50°F entering water</u>		<u>3.6 COP</u>	<u>ISO-13256-1</u>
<u>Ground source</u> <u>(heating mode)</u>	<u>< 135,000 Btu/h</u> <u>(cooling capacity)</u>	<u>32°F entering brine</u>	<u>2.5 COP</u>	<u>2.5 COP</u>	<u>ARI 330</u>
		<u>32°F entering brine</u>		<u>3.1 COP</u>	<u>ISO-13256-1</u>

For SI: 1 Btu/hr = 0.2931 W

- a. Chapter 9 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
- b. IPLVs are only applicable to equipment with capacity modulation.
- c. Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat.
- d. Single-phase air-cooled air-conditioners < 65,000 Btu/h are regulated by the National Appliance Energy Conservation Act of 1987 (NAECA). SEER values are those set by NAECA.

Eliminates old minimum efficiency column to eliminate confusion but carries the old EER ratings over into the new minimum efficiency column where there are blanks.

TABLE 803.2.2.(3)**PACKAGED TERMINAL AIR CONDITIONERS AND PACKAGED TERMINAL HEAT PUMPS**

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUB-CATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY^b	EFFICIENCY AS OF 10/29/2001^b	TEST PROCEDURE^a
<u>PTAC (cooling mode) new construction</u>	<u>All capacities</u>	<u>95°F db outdoor air</u>	<u>10.0 - (0.16 x Cap/1000) EER</u>	<u>12.5 - (0.213 x Cap/1000) EER</u>	<u>ARI 310/380</u>
<u>PTAC (cooling mode) replacements^c</u>	<u>All capacities</u>	<u>95°F db outdoor air</u>	<u>10.0 - (0.16 x Cap/1000) EER</u>	<u>10.9 - (0.213 x Cap/1000) EER</u>	
<u>PTHP (cooling mode) new construction</u>	<u>All capacities</u>	<u>95°F db outdoor air</u>	<u>10.0 - (0.16 x Cap/1000) EER</u>	<u>12.3 - (0.213 x Cap/1000) EER</u>	
<u>PTHP (cooling mode) replacements^c</u>	<u>All capacities</u>	<u>95°F db outdoor air</u>	<u>10.0 - (0.16 x Cap/1000) EER</u>	<u>10.8 - (0.213 x Cap/1000) EER</u>	
<u>PTHP (heating mode) new construction</u>	<u>All capacities</u>		<u>2.9 - (0.026 x Cap/1000) COP</u>	<u>3.2 - (0.026 x Cap/1000) COP</u>	
<u>PTHP (heating mode) replacements^c</u>	<u>All capacities</u>		<u>2.9 - (0.026 x Cap/1000) COP</u>	<u>2.9 - (0.026 x Cap/1000) COP</u>	

For SI: °C = [(°F) - 32] / 1.8, Btu/h = 0.2931W

- a.** Chapter 9 contains a complete specification of the reference test procedure, including the reference year version of the test procedure.
- b.** Cap means the rated cooling capacity of the product in Btu/h. If the unit's capacity is less than 7,000 Btu/h in the calculation. If the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculation.
- c.** Replacement units must factory labeled as follows: "MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS." Replacement efficiencies apply only to units with existing sleeves less than 16-in. (406 mm) high and less than 42-in (1067 mm) wide.

Eliminates old minimum efficiency column to eliminate confusion.

TABLE 803.2.2(4)**WARM AIR FURNACES AND COMBINATION AIR FURNACES/AIR-CONDITIONING UNITS, WARM AIR DUCT FURNACES AND UNIT HEATERS, MINIMUM EFFICIENCY REQUIREMENTS**

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUB-CATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY^d	EFFICIENCY AS OF 10/29/2001^{d,e}	TEST PROCEDURE
<u>Warm air furnace, gas fired</u>	<u>< 225,000 Btu/h</u>		<u>78% AFUE or 80% E_t^c</u>	<u>78% AFUE or 80% E_t^c</u>	<u>DOE 10 CFR Part 430 or ANSI Z21.47</u>
	<u>≥ 225,000 Btu/h</u>	<u>Maximum capacity^c</u>	<u>80% E_t</u>	<u>80% E_c^f</u>	<u>ASNI Z21.47</u>
<u>Warm air furnace, oil-fired</u>	<u>< 225,000 Btu/h</u>		<u>78% AFUE or 80% E_t^c</u>	<u>78% AFUE or 80% E_t^c</u>	<u>DOE 10 CFR Part 430 or UL 727</u>
	<u>≥ 225,000 Btu/h</u>	<u>Maximum capacity^c</u>	<u>81% E_t</u>	<u>81% E_t^g</u>	<u>UL 727</u>
<u>Warm air duct furnaces, gas fired</u>	<u>All capacities</u>	<u>Maximum capacity^b</u>	<u>78% E_t</u>	<u>80% E^c</u>	<u>ANSI Z83.9</u>
		<u>Maximum capacity^b</u>	<u>75% E_t</u>	<u>-----</u>	
<u>Warm air unit heaters, gas-fired</u>	<u>All capacities</u>	<u>Maximum capacity^b</u>	<u>78% E_t</u>	<u>80% E^c</u>	<u>ANSI Z83.8</u>
		<u>Maximum capacity^b</u>	<u>74% E_t</u>	<u>-----</u>	
<u>Warm air unit heaters oil-fired</u>	<u>All capacities</u>	<u>Maximum capacity^b</u>	<u>81% E_t</u>	<u>80% E^c</u>	<u>UL 731</u>
		<u>Maximum capacity^b</u>	<u>81% E_t</u>	<u>-----</u>	

For SI: 1 Btu/h=0.2931W

- a. Chapter 9 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
- b. Minimum and maximum ratings as provided for and allowed by the unit's controls.
- c. Combination units not covered by the National Appliance Energy Conservation Act of 1987 (NAECA) (3-phase power or cooling capacity greater than or equal to 65,000 Btu/h [19 kW]) shall comply with either rating.
- d. E_t = Thermal efficiency. See test procedure for detailed discussion.
- e. E_c = Combustion efficiency (100% less flue losses). See test procedure for detailed discussion.
- f. E_n = Combustion efficiency. Units must also include an IID, have jacket losses not exceeding 0.75% if the input rating, and have either power venting or a flue damper. A vent damper is an alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.
- g. E_t = Thermal efficiency. Units must also include an IID, have jacket losses not exceeding 0.75% if the input rating, and have either power venting or a flue damper. A vent damper is an alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.

Eliminates old minimum efficiency column to eliminate confusion.

TABLE 803.2.2.(5)**BOILERS, GAS- AND OIL-FIRED, MINIMUM EFFICIENCY REQUIREMENTS**

EQUIPMENT TYPE^f	SIZE CATEGORY (INPUT)	SUB-CATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY^{c, e}	EFFICIENCY AS OF 10/29/2001^d	TEST PROCEDURE
Boilers, gas-fired	< 300,000 Btu/h	Hot water	80% AFUE	80% AFUE	DOE 10 CFR Part 430
		Steam	75% AFUE	75% AFUE	
	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h	Maximum capacity^b	80% E_c	75% E_t	H.I. HBS 86
	> 2,500,000 Btu/h^f	Hot water	80% E_c	80% E_c	
		Steam	80% E_c	80% E_c	
Boilers, oil-fired	< 300,000 Btu/h		80% AFUE	80% AFUE	DOE 10 CFR Part 430
	≥ 300,000 Btu/h and ≤ 2,500,000	Maximum capacity^b	83% E_c	78% E_t	H.I. HBS 86
	> 2,500,000 Btu/h^f	Hot water	83% E_c	83% E_c	
		Steam	83% E_c	83% E_c	
Oil fire (Residual)	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h	Maximum capacity^b	83% E_c	78% E_t	H.I. HBS 86
	> 2,500,000 Btu/h^f	Hot water	83% E_c	83% E_c	
		Steam	83% E_c	83% E_c	

For SI: 1 Btu/h = 0.2931W

- a.** Chapter 9 contains a complete specification of the referenced test procedure, including the year version of the test procedure.
- b.** Minimum and maximum ratings as provided for and allowed by the unit's controls.
- c.** E_c = Combustion efficiency (100% less flue losses). See reference document for detailed information.
- d.** E_t = Thermal efficiency. See reference document for detailed information.
- e.** Alternate test procedures used at the manufacturer's option are ASME PTC-4.1 for units over 5,000,000 Btu/h input, or ANSI Z21.13 for units greater than or equal to 300,000 Btu/h and less than or equal to 2,500,000 Btu/h input.
- f.** These requirements apply to boilers with rated input of 8,000,000 Btu/h or less that are not packaged boilers, and to all packaged boilers. Minimum efficiency requirements for boilers cover all capacities of packaged boilers.

Eliminates old minimum efficiency column to eliminate confusion.

803.2.3.2 Humidity controls. When humidistats are installed, they shall prevent the use of fossil fuel or electric power to achieve a humidity below 60 percent when the system controlled is cooling, and above 30 percent when the system controlled is heating.

Deleted because it greatly increases the probable formation of mold in a hot and humid climate.

803.2.6 Cooling with outdoor air. Each system over 90,000 ~~65,000~~ Btu/h (26 379 W ~~19~~ kW) cooling capacity or 3,000 cfm (1416 L/s) located in other than Climate Zones 1, 2, or 3b, 5a or 6b as shown in Table 302.1 shall have an economizer that will automatically shut off the cooling system and allow all of the supply air to be provided directly from outdoors.

Economizers shall be capable of operating at 100 percent outside air, even if additional mechanical cooling is required to meet the cooling load of the building. Where a single room or space is supplied by multiple air systems, the aggregate capacity of those systems shall be used in applying this requirement.

Exceptions:

1. Where the cooling equipment is covered by the minimum efficiency requirements of Table 803.2.2(1) or 803.2.2(2) and meets the efficiency requirements of Table 803.2.6.
2. Systems with air or evaporatively cooled condensers and which serve spaces with open case refrigeration or that require filtration equipment in order to meet the minimum ventilation requirements of Chapter 4 of the *International Mechanical Code*.
3. Systems under 135,000 Btu/h (40 kW) cooling capacity in Climate Zones 3c, 5b, 7, 13b and 14.

803.2.8 Duct and plenum insulation and sealing. All supply and return air ducts and plenums shall be insulated with a minimum of R-5 insulation when located in unconditioned spaces and with a minimum of R-8 insulation when located outside the building envelope. When located within a building envelope assembly, the duct or plenum shall be separated from the building exterior or unconditioned or exempt spaces by a minimum of R-8 insulation according to Table 503.3.3.3.

Exceptions:

1. When located within equipment.
2. ~~When the design temperature difference between the interior and exterior of the duct or plenum does not exceed 15°F (8°C)~~ Return air ducts located in the conditioned space.

All joints, longitudinal and transverse seams, and connections in ductwork shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems, or tapes. Tapes and mastics used to seal ductwork shall be listed and labeled in accordance with UL 181A or UL 181B. Duct connections to flanges of air distribution system equipment shall be sealed and mechanically fastened. Duct tape is not permitted as a sealant on any metal ducts in accordance with the Houston Mechanical Code.

*Matches this Section's text to the Table 503.3.3 modified by the supplement.
Houston Mechanical Code sealing based on SMACNA method A requirements are more stringent.*

803.3.1.1 Equipment and system sizing. Heating and cooling equipment and system capacity shall not exceed the loads calculated in accordance with Section 803.2.1.

Exceptions:

1. Required standby equipment and systems provided with controls and devices that allow such systems or equipment to operate automatically only when the primary equipment is not operating.
2. Multiple units of the same equipment type with combined capacities exceeding the design load and provided with controls that have the capability to sequence the operation of each unit based on load.

Equipment sizing is not simple. There are many factors that enter into the choice of size beyond the raw calculations. It should be a matter between the owner and the designer of the system. This paragraph is not enforceable.

803.3.2 HVAC equipment performance requirements. Equipment shall meet the minimum efficiency requirements of Tables 803.3.2(1) through 803.3.2(3) 803.3.2(6) and Table 803.2.2(5), when tested and rated in accordance with the applicable test procedure. The efficiency shall be verified through data furnished by the manufacturer or through certification under an approved certification program, or if no certification program exists, the equipment efficiency rating shall be supported by data furnished by the manufacturer. Where multiple rating conditions and/or performance requirements are provided, the equipment shall satisfy all stated requirements. Where components, such as indoor or outdoor coils, from different manufacturers are used, calculations and supporting data shall be furnished by the designer that demonstrate the combined efficiency of the specified components meets the requirements herein.

Where unitary or prepackaged equipment is used in a complex HVAC system and is not covered by Section 803.3.2, the equipment shall meet the applicable requirements of Section 803.2.2.

Exception: Equipment listed in Table 803.3.2(2) not designed for operation at ARI Standard test conditions of 44°F (7°C) leaving chilled water temperature and 85°F (29° C) entering the condenser water temperature shall have a minimum full load COP and IPLV rating as shown in Tables 803.3.2(3) through 803.3.2(5) as applicable. The table values are only applicable over the following full load design ranges:

Leaving Chilled Water Temperature:	40 to 48 46 °F (4 to 9 °C)
---------------------------------------	----------------------------

Entering Condenser Water Temperature:	75 to 85 °F (24 to 29 °C)
--	---------------------------

Condensing Water Temperature Rise:	5 to 15 °F (-15 to -9 °C)
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Chillers designed to operate outside these ranges are not covered by this code.

Errata. The tables stop at 46°F.

TABLE 803.3.2 (1)**CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS**

EQUIPMENT TYPE	SIZE CATEGORY	MINIMUM EFFICIENCY^b	EFFICIENCY AS OF 10/29/2001^b	TEST PROCEDURE^a
Condensing units, air cooled	135,000 Btu/h	9.9 EER 11.0 IPLV	10.1 EER 11.2 IPLV	ARI 365
Condensing units, water and evaporatively cooled	135,000	12.9 EER 12.9 IPLV	13.1 EER 13.1 IPLV	

For SI: 1Btu/h = 0.2931W

- a. Chapter 9 contains a complete specification of the referenced test procedure, including the year version of the test procedure.
- b. IPLVs are only applicable to equipment with capacity modulation.

Eliminates old minimum efficiency column to reduce confusion.

TABLE 803.3.2(2)
WATER CHILLING PACKAGES, MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY	MINIMUM EFFICIENCY^b	EFFICIENCY AS OF 10/29/2001^b	TEST PROCEDURE^a
Air cooled, with condenser, electrically operated	< 150 tons	2.70 COP 2.80 IPLV	2.80 COP 2.80 IPLV	ARI 550 or ARI 590 as appropriate
	≥ 150 tons	2.50 COP 2.50 IPLV	2.50 COP 2.50 IPLV	
Air cooled, without condenser, electrically operated	All capacities	3.10 COP 3.20 IPLV	3.10 COP 3.10 IPLV	ARI 590
Water cooled, electrically operated, positive displacement (reciprocating)	All capacities	3.80 COP 3.90 IPLV	4.20 COP 4.65 IPLV	
Water cooled, electrically operated, positive displacement (rotary screw and scroll)	< 150 tons	3.80 COP 3.90 IPLV	4.45 COP 4.50 IPLV	ARI 550 or ARI 590 as appropriate
	≥ 150 tons and < 300 tons	4.20 COP 4.50 IPLV	4.90 COP 4.95 IPLV	
	≥ 300 tons	5.20 COP 5.30 IPLV	5.50 COP 5.60 IPLV	
Water cooled, electrically operated, centrifugal ^c	< 150 tons	3.80 COP 3.90 IPLV	5.00 COP 5.00 IPLV	ARI 550
	≥ 150 tons and < 300 tons	4.20 COP 4.50 IPLV	5.55 COP 5.55 IPLV	
	≥ 300 tons	5.20 COP 5.30 IPLV	6.10 COP 6.10 IPLV	
Air cooled absorption single effect	All capacities	0.48 COP	0.60 COP	
Water cooled absorption single effect	All capacities	0.60 COP	0.70 COP	
Absorption double effect, indirect fired	All capacities	0.95 COP 1.00 IPLV	1.00 COP 1.05 IPLV	ARI 560
Absorption double effect, indirect fired	All capacities	0.95 COP 1.00 IPLV	1.00 COP 1.00 IPLV	

For SI: 1 Ton = 3.517 kW

- a. Chapter 9 contains a complete specification of the referenced test procedure, including the year version of the test procedure.
- b. The chiller equipment requirements do not apply for chillers used in low temperature applications where the design leaving fluid temperature is less than or equal to 40°F (4°C).

Eliminates old minimum efficiency column to reduce confusion but carries the old EER ratings over into the new minimum efficiency column where there are blanks.

TABLE 803.3.2(3)**COPS AND IPLVS FOR NON-STANDARD CENTRIFUGAL CHILLERS < 150 TONS**

CENTRIFUGAL CHILLERS < 150 TONS COP _{std} = 5.4								
			CONDENSER FLOW RATE					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
Leaving chilled water temperature (°F)	Entering condenser water temperature (°F)	Lift ^a (°F)	Required COP and IPLV					
46	75	29	6.00	6.27	6.48	6.80	7.03	7.20
45	75	30	5.92	6.17	6.37	6.66	6.87	7.02
44	75	31	5.84	6.08	6.26	6.53	6.71	6.86
43	75	32	5.75	5.99	6.16	6.40	6.58	6.71
42	75	33	5.67	5.90	6.06	6.29	6.45	6.57
41	75	34	5.59	5.82	5.98	6.19	6.34	6.44
46	80	34	5.59	5.82	5.98	6.19	6.34	6.44
40	75	35	5.50	5.74	5.89	6.10	6.23	6.33
45	80	35	5.50	5.74	5.89	6.10	6.23	6.33
44	80	36	5.41	5.66	5.81	6.01	6.13	6.22
43	80	37	5.31	5.57	5.73	5.92	6.04	6.13
42	80	38	5.21	5.48	5.64	5.84	5.95	6.04
41	80	39	5.09	5.39	5.56	5.76	5.87	5.95
46	85	39	5.09	5.39	5.56	5.76	5.87	5.95
40	80	40	4.96	5.29	5.47	5.67	5.79	5.86
45	85	40	4.96	5.29	5.47	5.67	5.79	5.86
44	85	41	4.83	5.18	5.40	5.59	5.71	5.78
43	85	42	4.68	5.07	5.28	5.50	5.62	5.70
42	85	43	4.51	4.94	5.17	5.41	5.54	5.62
41	85	44	4.33	4.80	5.05	5.31	5.45	5.53
40	85	45	4.13	4.65	4.92	5.21	5.35	5.44
Condenser DT ^b			14.04	11.23	9.36	7.02	5.62	4.68

For SI: °C = [(°F) - 32] / 1.8

- a. Lift = Entering condenser water temperature °F - Leaving chilled water temperature °F.
- b. Condenser DT = Leaving condenser water temperature °F - Entering condenser water temperature °F
 $K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.00045595(X)$
 where X = Condenser DT + Lift
 $COP_{adj} = K_{adj} * COP_{std}$

TABLE 803.3.2(4)
COPS AND IPLVS FOR NON-STANDARD CENTRIFUGAL CHILLERS > 150 TONS, ≤ 300 TONS

CENTRIFUGAL CHILLERS < 150 TONS, ≤ 300 TONS								
COP_{std} = 5.55								
			CONDENSER FLOW RATE					
			2	2.5	3	4	5	6
Leaving chilled water temperature (°F)	Entering condenser water temperature (°F)	Lift^a (°F)	gpm/ton	gpm/ton	gpm/ton	gpm/ton	gpm/ton	gpm/ton
Required COP and IPLV								
46	75	29	6.17	6.44	6.66	6.99	7.23	7.40
45	75	30	6.08	6.34	6.54	6.84	7.06	7.22
44	75	31	6.00	6.24	6.43	6.71	6.90	7.05
43	75	32	5.91	6.15	6.33	6.58	6.76	6.89
42	75	33	5.83	6.07	6.23	6.47	6.63	6.75
41	75	34	5.74	5.98	6.14	6.36	6.51	6.62
46	80	34	5.74	5.98	6.14	6.36	6.51	6.62
40	75	35	5.65	5.90	6.05	6.26	6.40	6.51
45	80	35	5.65	5.90	6.05	6.26	6.40	6.51
44	80	36	5.56	5.81	5.97	6.17	6.30	6.40
43	80	37	5.46	5.73	5.89	6.08	6.21	6.30
42	80	38	5.35	5.64	5.80	6.00	6.12	6.20
41	80	39	5.23	5.54	5.71	5.91	6.03	6.11
46	85	39	5.23	5.54	5.71	5.91	6.03	6.11
40	80	40	5.10	5.44	5.62	5.83	5.95	6.03
45	85	40	5.10	5.44	5.61	5.83	5.95	6.03
44	85	41	4.96	5.33	5.55	5.74	5.86	5.94
43	85	42	4.81	5.21	5.42	5.66	5.78	5.86
42	85	43	4.63	5.08	5.31	5.56	5.69	5.77
41	85	44	4.45	4.93	5.19	5.46	5.60	5.69
40	85	45	4.24	4.77	5.06	5.35	5.50	5.59
Condenser DT^b			14.04	11.23	9.36	7.02	5.62	4.68

For SI: °C = [(°F) - 32] / 1.8

- a. Lift = Entering condenser water temperature °F - Leaving chilled water temperature °F.
- b. Condenser DT = Leaving condenser water temperature °F - Entering condenser water temperature °F
- $$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.00045595(X)$$
- where X = Condenser DT + Lift
- $$COP_{adj} = K_{adj} * COP_{std}$$

TABLE 803.3.2(5)
COPS AND IPLVS FOR NON-STANDARD CENTRIFUGAL CHILLERS > 300 TONS

CENTRIFUGAL CHILLERS > 300 TONS COP _{std} = 6.1								
			CONDENSER FLOW RATE					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
Leaving chilled water temperature (°F)	Entering condenser water temperature (°F)	Lift ^a (°F)	Required COP and IPLV					
46	75	29	6.80	7.11	7.35	7.71	7.97	8.16
45	75	30	66.71	6.99	7.21	7.55	7.78	7.96
44	75	31	6.61	6.89	7.09	7.40	7.61	7.77
43	75	32	6.52	6.79	6.98	7.26	7.45	7.60
42	75	33	6.43	6.69	6.87	7.13	7.31	7.44
41	75	34	6.33	6.60	6.77	7.02	7.18	7.30
46	80	34	56.33	6.60	6.77	7.02	7.18	7.30
40	75	35	6.23	6.50	6.68	6.91	7.06	7.17
45	80	35	6.23	6.50	6.68	6.91	7.06	7.17
44	80	36	6.13	6.41	6.58	6.81	6.95	7.05
43	80	37	6.02	6.31	6.49	6.71	6.85	6.94
42	80	38	5.90	6.21	6.40	6.61	6.75	6.84
41	80	39	5.77	6.11	6.30	6.52	6.65	6.74
46	85	39	5.77	6.11	6.30	6.52	6.65	6.74
40	80	40	5.63	6.00	6.20	6.43	6.56	6.65
45	85	40	5.63	6.00	6.20	6.43	6.56	6.65
44	85	41	5.47	5.87	6.10	6.33	6.47	6.55
43	85	42	5.30	5.74	5.98	6.24	6.37	6.46
42	85	43	5.11	5.60	5.86	6.13	6.28	6.37
41	85	44	4.90	5.44	5.72	6.02	6.17	6.27
40	85	45	4.68	5.26	5.58	5.90	6.07	6.17
Condenser DT ^b			14.04	11.23	9.36	7.02	5.62	4.68

For SI: °C = [(°F) - 32] / 1.8

- a. Lift = Entering condenser water temperature °F - Leaving chilled water temperature °F.
- b. Condenser DT = Leaving condenser water temperature °F - Entering condenser water temperature °F
- $K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.00045595(X)$
- where X = Condenser DT + Lift
- $COP_{adj} = K_{adj} * COP_{std}$

TABLE 803.3.2(6)**PERFORMANCE REQUIREMENTS FOR HEAT REJECTION EQUIPMENT**

Equipment Type	Total System Heat Rejection Capacity at Rated Conditions	Sub-Category or Rating Condition	Performance Required as of 10/29/2001^{a,b}	Test Procedure^c
Propeller or axial fan cooling towers	All	95°F (35°C) entering water 85°F (29°C) leaving water 75°F (24°C) wb outdoor air	≥38.2 gpm/hp (3.23 L/s · kW)	CTI ATC-103 and CTI STD-201
Centrifugal fan Cooling towers	All	95°F (35°C) entering water 85°F (29°C) leaving water 75°F (24°C) wb outdoor air		

For SI: °C = [(°F) - 32] / 1.8, 1 Btu/h = 0.2931W, 1 L/s·kW = 11.8 gpm/hp

- a. For purposes of this table, cooling tower performance is defined as the maximum flow rating of the tower units (gpm) divided by the fan nameplate rated motor power units (hp).
- b. For purposes of this table air-cooled condenser performance is defined as the heat rejected from the refrigerant units (Btu/h) divided by the fan nameplate rated motor power units (hp).
- c. Chapter 9 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

803.3.3.2 Set point overlap restriction. Where used to control both heating and cooling, zone thermostatic controls shall provide a temperature range or deadband of at least 5°F (Δ2.8°C) within which the supply of heating and cooling energy to the zone is capable of being shut off or reduced to a minimum.

Exception: Thermostats requiring manual changeover between heating and cooling modes.

Greatly increases the probable formation of mold in a hot and humid climate.

803.3.3.3.1 Thermostatic setback capabilities. Thermostatic setback controls shall have the capability to set back or temporarily operate the system to maintain zone temperatures down to 55 65°F (13°C ??°C) or up to 85°F (29°C).

Greatly increases the probable formation of condensation in a hot and humid climate.

803.3.3.5 Economizers. Economizers shall be provided on each system over 90,000 65,000 Btu/h [(26 375 W) 7.5 tons] (19 kW) cooling capacity or 3,000 cfm (1416 L/s) cfm in accordance with Section 803.2.6.

Exceptions:

1. ~~Water economizers that are capable of cooling supply air by direct or indirect evaporation or both and providing up to 100 percent of the expected system cooling load at outside air temperatures of 50°F (10°C) dry bulb/45°F (7°C) wet bulb and below.~~
2. ~~Systems under 135,000 Btu/h (40 kW) cooling capacity in Climate Zones 3c, 5b, 7, 13b, and 14.~~

Economizers need enthalpy controls to work and in a tropical hot and humid climate would create less efficiency because annual leakage would override any savings derived during the few days each year that an economizer would be beneficial.

803.3.3.6 Variable air volume (VAV) fan control. Individual VAV fans with motors of ~~25~~ 10 horsepower (hp) (~~18.8~~ 7.46 kW) or greater shall be driven by a mechanical or electrical variable speed drive; be a vane-axial fan with variable pitch blades; or have controls or devices that will result in fan motor demand of no more than 50 percent of their design wattage at 50 percent of design airflow, ~~when static pressure set point equals one-third of the total design static pressure.~~

More stringent requirement applied.

803.3.3.7 Hydronic systems controls. Individual hydronic heating and cooling units shall have separate hot water and chilled water supply and return piping. Systems shall not have the capability to supply hot and chilled water concurrently to any terminal unit.

Exception: Zones where special humidity levels are required to satisfy process and occupancy needs.

There are situations where special humidity levels need to be maintained based on occupancy such as schools and hospitals.

803.3.3.8 Heat rejection equipment fan speed control. Each fan powered by a motor of 7.5 hp (5.6 kW) or larger shall have the capability to operate that fan at two-thirds of full speed or less, and shall have controls that automatically change the fan speed to control the leaving fluid temperature or condensing temperature/pressure of the heat rejection device.

Exception: Factory installed heat rejection devices within HVAC equipment tested and rated in accordance with Tables 803.3.2(1) through 803.3.2(3).

803.3.4 Requirements for complex mechanical systems serving multiple zones. Systems serving multiple zones shall be VAV systems which, during periods of occupancy, are designed and capable of being

controlled to reduce primary air supply to each zone to a minimum before reheating, recooling or mixing takes place. Sections 803.3.4.1 through 803.3.4.4 shall apply to complex mechanical systems.

Exceptions:

1. Zones where special pressurization relationships or cross-contamination requirements are such that VAV systems are impractical.
2. Where at least 75 percent of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered or site-solar energy source.
3. Zones where special humidity levels are required to satisfy process or occupancy needs.
4. ~~Zones with a peak supply air quantity of 300 cfm (142 L/s) or less and where the flowrate is less than 10 percent of the total fan system supply airflow rate.~~
5. ~~Zones where the volume of air to be reheated, recooled, or mixed is no greater than the volume of outside air required to meet the minimum ventilation requirements of Chapter 4 of the *International Mechanical Code*.~~
6. Systems with zone thermostatic and humidistatic controls capable of operating in sequence the supply of heating and cooling energy to the zone and which are capable of preventing reheating, recooling, mixing or simultaneous supply of air that has been previously mechanically cooled and air that has been previously mechanically heated.

#3 - There are situations where special humidity levels need to be maintained based on occupancy such as schools and hospitals.

#4 and #5 - Reducing exceptions is more stringent.

~~803.3.4.1 Temperature reset for air systems.~~ Controls shall be provided that have the capability to automatically reset the supply air in response to measured parameters representative of building loads or by outside air temperature. Temperature shall be capable of being reset by at least 25 percent of the design supply air to room air temperature difference.

803.3.4.2 Single duct variable air volume (VAV) systems, terminal devices. Single duct VAV systems shall use terminal devices capable of reducing the supply of primary supply air before reheating or recooling takes place.

~~803.3.4.3~~ 803.3.4.2 Dual duct and mixing VAV systems, terminal devices. Systems that have one warm air duct and one cool air duct shall use terminal devices which are capable of reducing the flow from one duct to a minimum before mixing of air from the other duct takes place.

803.3.6 Duct and plenum insulation and sealing. All ducts and plenums shall be insulated and sealed in accordance with Section 803.2.8.

~~Ducts designed to operate at static pressures in excess of 3 inch water gauge (wg) (746 Pa) shall be leak-tested in accordance with the SMACNA HVAC Air Duct Leakage Test Manual with the rate of air leakage (CL) less than or equal to 6.0 as determined in accordance with Equation 8-2.~~

$$CL = F \times P^{0.65} \text{ (Equation 8-2)}$$

~~where:~~

~~F = The measured leakage rate in cfm per 100 square feet of duct surface.~~

~~P = The static pressure of the test.~~

~~Documentation shall be furnished by the designer demonstrating that representative sections totaling at least 25 percent of the duct area have been tested and that all tested sections meet the requirements of this section.~~

Houston's stricter standard for sealing meets the same intent as testing.

803.3.7 Piping insulation. All piping serving as part of a heating or cooling system shall be thermally insulated in accordance with Table 803.3.7.

Exceptions:

1. Factory-installed piping within HVAC equipment tested and rated in accordance with a test procedure referenced by this code.
2. Piping that conveys fluids that have a design operating temperature range between ~~55~~ 85°F (~~13~~ 27°C) and 105°F (41°C).
3. Piping that conveys fluids that have not been heated or cooled through the use of fossil fuels or electric power.
4. Hydronic heating runout piping not exceeding 4 feet (1219 mm) in length and 1 inch (25 mm) in diameter between the control valve and HVAC coil.

Limiting the exception is more stringent.

803.3.8 HVAC system completion. Prior to the issuance of a certificate of occupancy, the following shall be completed ~~by the design professional~~:

Procedural. The jurisdiction, not the code, needs to designate which plans require design professionals.

804.3 Temperature controls. Service water-heating equipment shall be provided with controls to allow a setpoint of ~~110~~ 120°F (43 ~~49~~°C) for equipment serving dwelling units and 90°F (32°C) for equipment serving other occupancies. The outlet temperature of lavatories in public facility rest rooms shall be limited to ~~110~~°F (43°C).

Required by the health department. Considered a life safety item as it affects public health. The 120 degree setting for hot water is established to kill bacteria and reduce the spread of disease.

805.2 Lighting controls. Lighting systems shall be provided with controls as required in Section 805.2.1, ~~and 805.2.2 and 805.2.3.~~

805.2.1 Interior lighting controls. Each area enclosed by walls or floor-to-ceiling partitions shall have at least one manual control for the lighting serving that area. The required controls shall be located within the area served by the controls or be a remote switch that identifies the lights served and indicates their status. Large spaces shall have a separate switch or control for each 2500 square feet of floor area.

Exceptions:

1. Areas designated as security or emergency areas that must be continuously lighted.
2. Lighting in stairways or corridors that are elements of the means of egress.

Increasing the number of switches allows greater control of lighting for users which may potentially improve efficiency.

805.2.2 Additional controls. Each area that is required to have a manual control shall have additional controls that meet the requirements of 805.2.2.1, 805.2.2.2 or 805.2.2.3.

Exceptions:

1. Areas that have only 1 luminaire.
2. Areas that are controlled by an occupant-sensing device.
3. Corridors, storerooms, restrooms, or public lobbies.

805.2.1.1 805.2.2.1 Bi-Level switching. Each area less than 250 ft² that is required to have a manual control shall also allow the occupant to reduce the connected lighting load in a reasonably uniform illumination pattern by at least 50 percent.

Exceptions:

1. Areas that have only \pm 2 luminaires or less.

2. Areas that are controlled by an occupant sensing device.
3. Corridors, storerooms, rest rooms, or public lobbies.
4. Guest rooms.

Although this has negligible impact, it does not make sense to have bi-level switching in typical small 10' x 12' offices that commonly have 2 fixtures.

805.2.2.2 Automatic lighting shutoff. Spaces greater than 250 ft² (23 m²) in buildings larger than 5,000 ft² (465 m²) shall be equipped with an automatic control device to shut off lighting in those areas. This automatic control device shall function on either:

1. A scheduled basis, using time-of-day, with an independent program schedule that controls the interior lighting in areas that do not exceed 25,000 ft² (2323 m²) and are not more than one floor, or
2. An unscheduled basis by occupant intervention.

805.2.1.2 805.2.2.3 Guest rooms Sleeping units. Guest rooms Sleeping units in hotels, motels, boarding houses or similar buildings shall have at least one master switch at the main entry door that controls all permanently wired lighting fixtures and switched receptacles, except those in the bathroom(s). Suites shall have a control meeting these requirements at the entry to each room or at the primary entry to the suite.

Renumbered to fall in sequence with supplement changes. Term changed to match building code terminology.

INTERNATIONAL RESIDENTIAL CODE

CHAPTER 11 ENERGY EFFICIENCY

N1101.2 Compliance. Compliance with this chapter shall be demonstrated by meeting the requirements of the applicable sections and tables of this chapter. Where applicable, provisions are based on the climate zone 3, where the building is located. The climate zone where the building is located shall be based on zone assignments in Table N1101.2 for the county and state in which the building is being constructed.

Alternatively, the climate zone shall be permitted to be determined by the Heating Degree Days assigned by the building official.

The zone is established by NOAA data from Houston Hobby Airport.

N1101.3.2.1 Default fenestration performance. When a manufacturer has not determined a fenestration product's *U*-factor in accordance with NFRC100, compliance shall be determined by assigning such products a default *U*-factor from Tables ~~102.5.2~~ N1101.3.2.1 (1) and ~~102.5.2~~ N1101.3.2.1 (2) in the *International Energy Conservation Code*. When manufacturer has not determined a fenestration product's SHGC in accordance with NFRC 200, compliance shall be determined by assigning such products a default SHGC from Table ~~102.5.2(3)~~ N1101.3.2.1(3) of the *International Energy Conservation Code*.

For convenience, the IECC default tables will be inserted here in the IRC.

Table N1101.3.2.1(1)

U- Factor Default Table for Windows, Glazed Doors and Skylights

<u>FRAME MATERIAL AND PRODUCT TYPE</u>	<u>SINGLE GLAZED</u>	<u>DOUBLE GLAZED</u>
<u>Metal without thermal break</u>		
<u>Operable (including sliding and swinging glass doors)</u>	<u>1.27</u>	<u>0.87</u>
<u>Fixed</u>	<u>1.13</u>	<u>0.69</u>
<u>Garden window</u>	<u>2.60</u>	<u>1.81</u>
<u>Curtain wall</u>	<u>1.22</u>	<u>0.79</u>
<u>Skylight</u>	<u>1.98</u>	<u>1.31</u>
<u>Site-assembled sloped/overhead glazing</u>	<u>1.36</u>	<u>0.82</u>
<u>Metal with thermal break</u>		
<u>Operable (including sliding and swinging glass doors)</u>	<u>1.08</u>	<u>0.65</u>
<u>Fixed</u>	<u>1.07</u>	<u>0.63</u>
<u>Curtain wall</u>	<u>1.11</u>	<u>0.68</u>
<u>Skylight</u>	<u>1.89</u>	<u>1.11</u>
<u>Site-assembled sloped/overhead glazing</u>	<u>1.25</u>	<u>0.70</u>
<u>Reinforced vinyl/metal clad wood</u>		
<u>Operable (including sliding and swinging glass doors)</u>	<u>0.90</u>	<u>0.57</u>
<u>Fixed</u>	<u>0.98</u>	<u>0.56</u>
<u>Skylight</u>	<u>1.75</u>	<u>1.05</u>

<u>Wood/vinyl/fiberglass</u>		
<u>Operable (including sliding and swinging glass doors)</u>	<u>0.89</u>	<u>0.55</u>
<u>Fixed</u>	<u>0.98</u>	<u>0.56</u>
<u>Garden window</u>	<u>2.31</u>	<u>1.61</u>
<u>Skylight</u>	<u>1.47</u>	<u>0.84</u>

a. Glass block assemblies with mortar but without reinforcing or framing shall have a *U*-factor of 0.60.

Table N1101.3.2.1(2)

U- Factor Default Table for Nonglazed Doors

<u>DOOR TYPE</u>	<u>WITH FOAM CORE</u>	<u>WITHOUT FOAM CORE</u>
<u>Steel doors (1.75 inches thick)</u>	<u>0.35</u>	<u>0.60</u>
	<u>WITHOUT STORM DOOR</u>	<u>WITH STORM DOOR</u>
<u>Wood doors (1.75 inches thick)</u>		
<u>Panel with 0.438-inch panels</u>	<u>0.54</u>	<u>0.36</u>
<u>Hollow core flush</u>	<u>0.46</u>	<u>0.32</u>
<u>Panel with 1.125-inch panels</u>	<u>0.39</u>	<u>0.28</u>
<u>Solid core flush</u>	<u>0.40</u>	<u>0.26</u>

For SI: 1 inch = 25.4 mm.

TABLE N1101.3.2.1(3)

SHGC DEFAULT TABLE FOR FENESTRATION

<u>PRODUCT DESCRIPTION</u>	<u>SINGLE GLAZED</u>				<u>DOUBLE GLAZED</u>			
	<u>Clear</u>	<u>Bronze</u>	<u>Green</u>	<u>Gray</u>	<u>Clear</u>	<u>Bronze</u>	<u>Green</u>	<u>Gray</u>
					<u>+</u>	<u>+</u>	<u>+</u>	<u>+</u>
					<u>Clear</u>	<u>Clear</u>	<u>Clear</u>	<u>Clear</u>
<u>Metal frames</u>								
<u>Operable</u>	<u>0.75</u>	<u>0.64</u>	<u>0.62</u>	<u>0.61</u>	<u>0.66</u>	<u>0.55</u>	<u>0.53</u>	<u>0.52</u>

HOUS

Change the table below as noted. The remainder of table to remain unchanged.

Fixed	0.78	0.67	0.65	0.64	0.68	0.57	0.55	0.54
Nonmetal frames								
Operable	0.63	0.54	0.53	0.52	0.55	0.46	0.45	0.44
Fixed	0.75	0.64	0.62	0.61	0.66	0.54	0.53	0.52

N1102.1 Thermal performance criteria. The minimum required insulation *R*-value or maximum required *U*-factor for each element in the building thermal envelope (fenestration, roof/ceiling, opaque wall, floor, slab edge, crawl space wall and basement wall) shall be in accordance with the criteria in Table N1102.1. N101.4.2.5 of the *International Energy Conservation Code*.

Residential buildings, Type A-1, with greater than 15- percent glazing area; residential buildings, Type A-2, with greater than 25-percent glazing area; ~~and any residential building in climates with HDD equal to or greater than 13,000;~~ shall determine compliance using the building envelope requirements of the *International Energy Conservation Code*.

Default tables will be in the IRC.
Reference to HDD does not apply.

Change the table below as noted. The rest of table to remain unchanged.

Table N1102.1

Simplified Prescriptive Building Envelope Thermal Criteria Minimum Required Thermal Performance (*U*-Factor and *R*-Factor)

HDD	MAXIMUM GLAZING U-FACTOR [Btu/ (hr · ft ² · °F)]	MINIMUM INSULATION R-VALUE [(hr · ft ² · °F) /Btu]					
		Ceilings	Walls	Floors	Basement Walls	Slab perimeter R-value and depth	Crawl space walls
1,000-1,499*	0.75	R-19	R-11	R-11	R-0	R-0	R-5

For SI: 1 Btu/(hr · ft² · °F) = 5.68 W/m² · K, 1 (hr · ft² · °F) /Btu = 0.176m² · K/W.

*City of Houston HDD.

Clarifies which part of the table applies locally for users of code.

TABLE N1102.1.1.1(1)
MASS WALL PRESCRIPTIVE BUILDING ENVELOPE REQUIREMENTS

BUILDING LOCATION		MASS WALL ASSEMBLY R-VALUE ^a (hr·ft ² ·°F)	
Zone	HDD	Exterior or integral insulation	Other mass walls
3 ^b	1000-1499	R-4.8	R-9.7

For SI: $1(\text{hr} \cdot \text{ft}^2 \cdot ^\circ\text{F})/\text{Btu} = 0.176\text{m}^2\cdot\text{K}/\text{W}$.

- a. The sum of the value in Table N1102.1.1.1(2) and additional insulation layers.
- b. City of Houston zone as established in Section N1101.2.

Clarifies which part of the table applies locally for users of code.

N1102.2 Maximum solar heat gain coefficient for fenestration products. The area-weighted-average solar heat gain coefficient (SHGC) for glazed fenestration installed in climate zones 1 and 2 (to a maximum of 3,500 HDD) shall not exceed 0.40.

N1102.4 Replacement fenestration. Where an entire fenestration product, including frame, sash and glazed portion, is being replaced in an existing building, the replacement fenestration product shall have a *U*-factor that does not exceed a maximum fenestration *U*-factor of 0.75, the "Maximum fenestration *U*-factor" in Table 502.2.5 of the 2000 *International Energy Conservation Code* applicable to the climate zone (HDD) where

Simplifies the section by eliminating reference to HDD.

the building is located. Replacement skylights and roof windows shall be permitted to have a maximum *U*-factor of 0.50 when installed in any location above 1,999 HDD. The replacement fenestration products must also satisfy the SHGC and air leakage requirements of Sections N1102.2 and N1101.3.2.2, respectively.

Prescriptive path for additions and window replacements. Additions with a conditioned floor area less than 500 square feet (46.5 m²) to existing single-family residential buildings and structures shall meet the prescriptive envelope component criteria in Table N1102.4 for the designated heating degree days (HDD) applicable to the location. The *U*-factor of each individual fenestration product (windows, doors and skylights) shall be used to calculate an area-weighted average fenestration product *U*-factor for the addition, which shall not exceed the applicable listed values in Table N1102.4. For additions, the total area of fenestration products shall not exceed 40 percent of the gross wall and roof area of the addition. The *R*-values for opaque thermal envelope components shall be equal to or greater than the applicable listed values in Table N1102.4. Replacement fenestration products (where the entire unit, including the frame, sash and glazing, is replaced) shall meet the prescriptive fenestration *U*-factor criteria in Table N1102.4 for the designated HDD applicable to the location. Conditioned sunroom additions shall be served by a separate heating or cooling system, or shall be controlled as separate zone of the existing system.

Utilizes supplement change to IECC. Section 502.2.5 to coordinate similar provisions of IECC and IRC.

Table N1102.4

**PRESCRIPTIVE ENVELOPE COMPONENT CRITERIA ADDITIONS TO AND REPLACEMENT WINDOWS FOR
EXISTING SINGLE-FAMILY RESIDENTIAL BUILDINGS**

HEATING DEGREE DAYS	MAXIMUM	MINIMUM					
	Fenestraion <i>U-factor</i>^e	Ceiling <i>R-value</i>^a	Wall <i>R-value</i>	Floor <i>R-value</i>	Basement wall <i>R-value</i>^b	Slab Perimeter <i>R-value</i> and Depth^c	Crawl Space Wall <i>R-value</i>^d
<u>0-1,999</u>	<u>0.75</u>	<u>R-26</u>	<u>R-13</u>	<u>R-11</u>	<u>R-5</u>	<u>R-0</u>	<u>R-5</u>

For SI: 1 foot = 304.8 mm.

- a. "Ceiling *R-value*" shall be required for flat or inclined (cathedral) ceilings. Floors over outside air shall meet "Ceiling *R-value*" requirements.
- b. Basement wall insulation shall be installed in accordance with Section 1102.1.5.
- c. Slab perimeter insulation shall be installed in accordance with Section 1102.1.4. An additional R-2 shall be added to "Slab perimeter *R-value*" in the table if the slab is heated.
- d. "Crawl space wall *R-value*" shall apply to unventilated crawl spaces only. Crawl space insulation shall be installed in accordance with Section 1102.1.7.
- e. Sunroom additions shall be required to have a minimum *U-factor* of 0.50.

IECC Table included which combines additions with window replacement. Adding the table for additions allows users to stay in the IRC for additions

*In footnote e, this *U-factor* for sunrooms will be required in Houston increasing the stringency of the code.*

TABLE N1103.5
MINIMUM PIPE INSULATION
(thickness in inches)

PIPING SYSTEM TYPES	FLUID TEMPERATURE RANGE, °F	Pipe Sizes ^{a, c}					
		Runouts up to 2" ^b	1 and less	1.25" to 2"	2.5" to 4"	5" to 6"	8" and larger
HEATING SYSTEMS							
Steam and hot water:							
High pressure/temperature	306-450	1 ½	2 ½	2 ½	3	3 ½	3 ½
Medium pressure/temperature	251-305	1 ½	2	2 ½	2 ½	3	3
Low pressure/temperature	201-250	1	1 ½	1 ½	2	2	2
Low temperature	106 - 200	½	1	1	1 ½	1 ½	1 ½
Steam condensate (for feed water)	Any	1	1	1 ½	2	2	2
COOLING SYSTEMS							
Chilled water, refrigerant and brine:	40-55	½	½	¾	1	1	1
	Below 40	1	1	1 ½	1 ½	1 ½	1 1/2

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, °C = [(°F)-32]/1.8.

a. For piping exposed to outdoor air, increase insulation thickness by 0.5 inch.

b. Runouts not exceeding 12 feet in length to individual terminal units.

Replaces table in IRC to conform with supplement change in the corresponding section of the IECC.

The Following appendices are available in hard copy.

APPENDIX I - NOAA DATA

APPENDIX II - MECHANICAL CODE SECTION ON SEALING REQUIREMENTS

APPENDIX III - SMACNA METHOD “A”